ELECTRICAL ENGINEERING

JULY 1956
Vol. 75, No. 7

Published monthly by American Institute of Electrical Engineers

Contents

An Operating Utility Viewpoint — *M. D. Hooven*
Spot checks of engineers' activities in an operating utility, as well as their ideas on education, provide information for future training 595

Voltage Dips and Flicker — *A. A. Kroneberg*
A discussion of the public utility's problems in providing constant voltage, with specific reference to industrial consumers 599

What Is an Air-Conditioning Horsepower? — *P. W. Wyckoff*
Horsepower of an air conditioner has little connection with ability to cool, so that ratings of each type should be determined 602

Some Basic Aspects of Numerical Machine-Tool Control — *L. W. Herchenroeder*
Programming of machine tools using binary or decimal form on magnetic tape or cards has found many applications in industry 608

Automation and Machine Control Gauging — *W. C. Mullin*
For greater efficiency, badly machined parts can either be prevented or separated out by use of automatic and machine-control gauging 611

Flight Safety Aspects of Electrical Design — *W. F. Funk*
Following analysis of failures of electric systems for aircrafts, attention can be given to safer designs and testing policies 616

Adjustable-Voltage Hoist Drives for Cranes — *S. Rifkin*
Only recently have adjustable-voltage hoist drives for cranes been made practical in industry on a cost basis 620

Distributing Large Single-Phase Loads in Limited Capacity Three-Phase Power Systems — *G. F. Aroyan, K. G. Lakey*
If a large single-phase load alters a three-phase power system, this conversion method balances the system automatically 624

Economics of Distribution Systems — *P. F. Larson*
Factors having the most significant effects on first costs of an industrial power distribution system are discussed 630

Useful Applications of a Magnetic Drum Computer — *Stanley Frankel*
A description of the principles and operation of magnetic drum digital computers, including a detailed explanation of the *LGP-30* 634

THE COVER: One of the world's largest analogue computers checks out advanced-design jet engines before they are built. The engineer makes an adjustment in one section of the giant computer, which has 27 miles of wire, 6,000 vacuum tubes, 300,000 soldered connections, and its own air-conditioning system. Story appears on page 659.

CONTENTS CONTINUED

ELECTRICAL ENGINEERING: © Copyright 1956 by the American Institute of Electrical Engineers; printed in the United States of America; indexed annually by the AIEE, weekly and annually by *Engineering Index*, and monthly by *Industrial Arts Index;* abstracted monthly by *Science Abstracts* (London). Address changes must be received at AIEE headquarters, 33 West 39th Street, New York 18, N.Y., by the first of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge.

Mr. C. J. Cox (at right, above) supervises the installation of Okonite Splicing Tape on 2300 volt motor lead in Seabrook Farms food freezing plant. For 29 years Mr. Cox has standardized on Okonite splicing materials to assure water-tight seals on cables throughout the plant. Note moisture conditions indicated by frozen condensation on pump head.

Okonite Tapes resist moisture, freezing...

keep world's largest food freezing plant operating

For 29 years, Mr. C. J. Cox, supervisor of all construction and engineering for Seabrook Farms Co., has depended on Okonite Tapes to maintain the vast electrical network that keeps the world's largest food freezing plant operating. All electrical circuits (totaling 20,000 h.p. connected load), lights, as well as power for the motors and pumps which provide continuous freezing and storage capacity, are spliced and terminated with waterproof Okonite Tapes to assure positive protection against the moisture always present in the plant.

In every phase of Seabrook's operation, moisture is a problem. Treatment of food, freezing, processing, storing . . . all are damp operations with continuous condensation on cables and equipment alike. Low temperatures of the freezing and holding rooms make splicing difficult.

Okonite Tapes offer effective waterproof splices that are not affected by dampness or low temperatures. Both Okonite Rubber Tape and Okolite High Voltage Tape fuse into a solid self-vulcanizing wall of tough, waterproof insulation. Protected by Manson Friction Tape, splices maintain their moisture resistance through many years of exposure to condensation and freezing temperatures.

Try them on your own splices—write for this free box of 4 sample tapes to The Okonite Company, EG Tape Department, Passaic, N. J.

OKONITE splicing materials

3521

Contents Continued

Technical Paper Digests

Characteristics of Smooth Bundled Conductors	*C. J. Miller, Jr.*	598
Conductor Vibration Damping	*J. S. Tompkins, L. L. Merrill, B. L. Jones*	607
An Economic Study of High-Voltage Transmission	*A. J. Wood, J. M. Henderson*	615
Contactor Servo Describing-Function Theory	*S. K. Chao*	619
Internal Fault Currents of A-C Motors	*R. A. Schmidt*	628
Electrical Resistance to Earth of a Tree	*F. M. Defandorf*	629
Corrosion of Insulator and Conductor Hardware	*A. W. Bardeen, J. M. Sheadel*	633

News Index

Institute Activities	640
North Eastern District Holds Successful Meeting in Rochester, N. Y.	640
Electronic Components Symposium Held May 1–3	643
New AIEE Technical Division Approved by Board of Directors	644
Fall General Meeting Committee	645
Conference Papers Open for Discussion	646
AIEE Luncheon Honors President and Secretary of IEE	646
Future AIEE Meetings	649
Committee Activities	649
AIEE Fellows Elected	651
AIEE Personalities	651
Obituaries	652
Membership	652
In Educational Circles	653
AIEE-IRE Hold Annual Joint Student Activities Day	653
North West District Paper Contest Held May 12	653
AIEE Student Branch Meeting at MSOE	655
Providence Section Sponsors Annual Student Night	656
Of Current Interest	657
TALOS Guided Missile Air Defense Products Demonstrated	657
Jet Engine Testing Computer Developed for ARDC	659
Future Meetings of Other Societies	659
Nuclear Power Plant Visited by Sir Edwin Plowden	660
Highway Safety Is Human Engineering Problem	661
Air-to-Air Guided Missile Guards Fleet and U. S. Coast	662
Fraction-of-an-Inch Control Operates Jib Crane	663
Outstanding Television Sessions at S.M.P.T.E. Meeting	664
Plane within Plane Tests Jet Interceptors	666
Nuclear Power Plants for Minnesota and Michigan Electricity	668
Monofio Conveyor Protects Atomic Scientists	670
Letters to the Editor	672
New Books	674
Pamphlets	676
Industrial Notes	14A
New Products	30A
Trade Literature	38A
Index to Advertisers	90A

Charles S. Rich
Editor and Manager of Publications

G. C. Baxter Rowe
Associate Editor

Editorial Assistants

A. M. Fallert

M. M. Hatch

E. Reichman

V. S. Tavitian

R. E. Whitlock

J. S. Lopes
Advertising Director

W. E. Maginn
Eastern Advertising Director

Albert E. DelGado
Mid-West Advertising Director
1911 Noyes St.
Evanston, Ill.

Thomas P. Galavan
A. O. Dillenbeck, Jr.
West Coast Adv. Office
635 S. Kenmore Ave.
Suite 201
Los Angeles 5, Calif.
Tel: DUnkirk 5-3991

M. R. Rodgers
Advertising Production Manager

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Headquarters
33 West 39th Street
New York 18, N. Y.

Founded 1884

Editorial Offices
500 Fifth Avenue
New York 36, N. Y.

M. D. HOOVEN, President — N. S. HIBSHMAN, Secretary

PUBLICATION COMMITTEE: W. Scott Hill, *Chairman* J. D. Tebo, *Vice-Chairman* E. W. Boehne J. G. Brainerd
D. T. Braymer J. L. Callahan H. W. Codding C. E. Dean W. F. Denkhaus E. T. B. Gross
M. F. Kent R. E. Kistler M. G. Malti H. N. Muller, Jr. C. S. Rich Victor Siegfried S. A. Tucker

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 36, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. July 1956, Vol. 75, No. 7. Number of copies of this issue 65,000

NUCLEAR NEWS FROM ATOMICS INTERNATIONAL

Industry's First Private Research Reactor Now in Operation

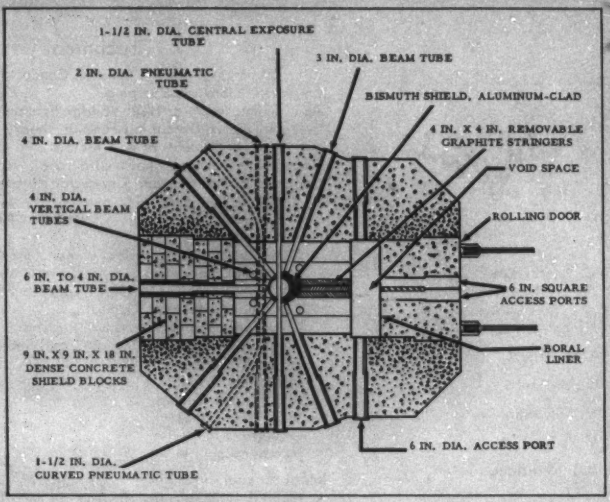
The Armour Research Foundation's nuclear reactor, located on the Illinois Institute of Technology Campus on State Street near Chicago's Loop, began operating early this spring. This marked the first time that private industry has had at its disposal a nuclear reactor expressly designed for industrial research.

Already under way at Armour are programs by participating companies, taking advantage of the revolutionary research techniques made possible by the new facility. The schedule includes allocation of reactor "time" for private studies, free of security restrictions. Areas of study include: food and drug processing; materials research – glass, ceramics, plastics, rubber, textiles, etc; petroleum, chemicals and other industrial materials and processes.

The Model L8 Armour reactor is of the homogeneous solution type, designed to operate at 50 KW and to produce a maximum thermal neutron flux of about 1.7×10^{12} neutrons/cm²-sec at the center of the reactor core. Exposure facilities are provided through which the neutron flux is available in varying intensities for experimental purposes. Power level is controlled either manually or automatically by a vertical control-rod system. The reactor is safeguarded by a unique control system which "scrams," or automatically shuts down the reactor, if necessary.

One of several reactors produced by ATOMICS INTERNATIONAL, a Division of North American Aviation, Inc., the design and construction of the L8 Model is based on the company's 10 years' experience in the development of peaceful applications of nuclear energy. Other applications include a reactor designed for a prominent southern California university, specially adapted for cancer and other medical research; the important Sodium Reactor Experiment in the Santa Susana Mountains near Los Angeles, part of the AEC program to develop economical power from nuclear energy; plus development and design of a 75,000 KW sodium-graphite nuclear power plant.

ATOMICS INTERNATIONAL is a major reactor builder—experienced in the design, construction and operation of nuclear reactors for research and the production of power.


1-1/2 IN. DIA. CENTRAL EXPOSURE TUBE
3 IN. DIA. BEAM TUBE
2 IN. DIA. PNEUMATIC TUBE
BISMUTH SHIELD, ALUMINUM-CLAD
4 IN. DIA. BEAM TUBE
4 IN. X 4 IN. REMOVABLE GRAPHITE STRINGERS
VOID SPACE
4 IN. DIA. VERTICAL BEAM TUBES
ROLLING DOOR
6 IN. TO 4 IN. DIA. BEAM TUBE
6 IN. SQUARE ACCESS PORTS
9 IN. X 9 IN. X 18 IN. DENSE CONCRETE SHIELD BLOCKS
BORAL LINER
6 IN. DIA. ACCESS PORT
1-1/2 IN. DIA. CURVED PNEUMATIC TUBE

Reactor Plan View

ARMOUR RESEARCH REACTOR MODEL L8

Characteristics

Design Power	50 kw
Zero Power Critical Mass*	850 gm U^{235}
Maximum Thermal Neutron Flux	1.7×10^{12} n/cm²-sec
Mass Coefficient of Reactivity*	0.03%/gm
Temperature Coefficient of Reactivity*	–0.029%/°C
Fuel Solution Temperature at 50 kw*	80° C
Excess Reactivity at 20° C, Zero Power*	3%
Reactivity Held in Control and Safety Rods*	8% (2% each rod)
H : U^{235} Atomic Ratio*	350
U^{235} Concentration*	75gm/liter
Power Density, Maximum	5.5 watt/cm³
Power Density, Average	3.85 watt/cm³

Approximate Value

Brief General Description—The reactor fuel is a light water solution of UO_2SO_4, enriched in U^{235}. This fuel is contained in a spherical stainless steel core tank, which is surrounded by a graphite reflector. The reactor is shielded with high density concrete (density 3.5 gm/cm³) plus other selected materials. Fuel-handling, gas-handling and cooling systems are provided; also complete instrumentation and equipment are installed for remote operation and to provide automatic safety action.

Experimental Facilities—The experimental facilities include nine assorted beam tubes, 3" to 6" ID; straight and curved pneumatic tubes, 1½" and 2" ID; central exposure tube; horizontal thermal column 5' square, with four 6" access ports. In addition there are special exposure facilities which make use of the gamma activities in the reactor atmosphere.

If you are interested in any phase of our activities, ATOMICS INTERNATIONAL is staffed and equipped to help you. Please write: Applications Engineering Service, Dept. EE-N3, ATOMICS INTERNATIONAL, P. O. Box 309, Canoga Park, California. Cable address: ATOMICS.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM

Please mention ELECTRICAL ENGINEERING when writing to advertisers

An Operating Utility Viewpoint

M. D. HOOVEN
PRESIDENT AIEE

Analyses of what engineers do in an operating utility and how their talents work out to their own and the community's best advantages are important, when considering how engineers in colleges are to be trained for the utility field.

TRADITIONALLY, the operating utilities, both communications and power, have employed the largest numbers of engineers. Training courses for engineering graduates in these fields are at least 40 years old. These industries have a long background of study and concern about the education of the young engineer.

However, one individual, at least this one, cannot answer directly or categorically the question of how engineers in college are to be trained for this field, because personal opinion enters into the problem to a high degree.

Consequently, I should qualify myself as to the areas of expertness which I can discuss. As to limits in my personal area of coverage, it must be recognized that I am not an educator. You who are qualified in that field should interpret any material that I might lay before you concerning what is required of the graduate engineers whom you teach. I am, however, an expert in the area of knowing what engineers do in an operating utility and how their talents work out to their own and the community's best advantage. For 35 years, I have been engaged in what is known as utility operating engineering in the power field. Early in that same period, I spent much time in inductive co-ordination, working out actual problems, mechanical and electrical, of joint interest with the telegraph and telephone companies and the railroads. It was my good fortune to become rather intimately acquainted with the operating staffs of many utilities of all kinds. Although I shall discuss largely experiences with engineers in the power utility field, my best judgment indicates that, broadly speaking, operating engineers in all utility fields have much in common.

OPERATING ENGINEERING

OPERATING ENGINEERING perhaps should be described first. Remember that the prime objective of the operating utility is to provide service to the people in its territory. Problems of meeting demands at all times are first in importance, whether they be for communication or power. The engineering talent in utilities thus is devoted to analyses of system growth, system design, and the application of equipment to meet such requirements.

This is the general problem: In a power utility there must be a source for power—a generating station, for instance, with its infinitely complex problems of economics and control—transportation of that power to the centers where it is needed, and the distribution from those centers to industries and residences. Involved is much equipment and many wires and cables. The same is true of the communications company. Very little, if any, pure research is done by the operating engineer. On the other hand, there is a tremendous amount of planning and development work in the electrification and extension of a system of supply. An operating company does very little design of pieces of equipment; however, the assembly of this equipment into a system requires an enormous amount of design. Analyses of operations result in planning, design, and development to supply better and more eco-

Full text of an address given before the Spring Meeting of the Middle Atlantic Section of the American Society of Engineering Education, Bell Telephone Laboratories, Murray Hill, N. J., May 12, 1956.

M. D. Hooven is with the Public Service Electric and Gas Company, Newark, N. J.

nomical service. Equipment manufacturers, continuously in the process of marketing new and better apparatus, do most of the development work; the operating engineer, to succeed in his work, must keep in constant touch with such improvements. His contribution to this field of engineering comes largely in stating his requirements for new developments and in applying these new products to existing systems.

Whereas practices in administering engineering talent vary widely, a most common practice in this field is known as sponsor engineering or project engineering. An individual engineer or an individual group of engineers handles one project, whether it be a study of a procedure or an installation of a specific job. In many cases, the sponsor or project engineer, insofar as engineering responsibility goes, acts as a kind of chief engineer.

THE ENGINEER'S TIME

To obtain a brief but reasonably specific picture of what engineers in my most intimate connection actually do, I have had a spot survey made of what a large group of people in this field are doing at the present time. Involved are a total of perhaps 200 engineers with whom I have close association; the spot survey itself included about 100 people.

The arithmetical results of the spot survey become easily understandable. On all jobs, roughly one third of an engineer's time was devoted to work which required his full formal engineering education in varying degrees of depth. Because of the great use of material developed by others, another third of an engineer's time requires so-called practical knowledge. Practical knowledge, in this case, means familiarity with actual apparatus and operating procedure—a familiarity which can be gained only with close personal contact. Disappointingly, perhaps, one quarter of an engineer's time seems to be devoted to clerical work. It is understandable, for instance, that in the installation of a given substation which uses transformers, circuit breakers, relays, measuring instruments, and similar items from many manufacturers, the actual burden of obtaining technical information, blueprints, and operating qualifications requires a great deal of correspondence. It is obvious, also, that merely to obtain these items through proper purchasing procedure requires an immense amount of dull routine. In reviewing operating results, it is equally obvious that a long history of past experience must be tabulated and analyzed.

This clerical requirement has caused deep anxiety among operating engineers for many years. Attempts now are being made all over the country to assign this type of work to technicians and clerks, leaving the engineer free to exercise his engineering talents. The difficulty, however, is this: In a complex engineering structure well spread out geographically, the fundamental knowledge and experience of an engineer seems to be required to interpret and follow the large amount of clerical work necessary. Even if the millenium were reached, it is doubtful that a quality of aid could be provided sufficient to reduce an engineer's clerical duties to less than 10 per cent.

The primary item of interest for this group is, of course, how the 75 per cent of the engineer's time spent on engineering is allocated. It appears that one half is devoted to application. Application, as used here, means the choice and use of an item provided by manufacturers to a specific requirement of an electric system. This may mean the choice of a conductor, a piece of apparatus, or the interrelation of both. To make it simple, in a given situation it is easy to conceive of a comparison of two plans, one of which uses a multiplicity of conductors and little equipment, the other using but little conductor equipment. This exercise of choice is an attractive and piquant job. It involves planning, development, and design—all combined in an intense drive to reach the best engineering solution. It is creative in somewhat the same sense that an artist's completion of a picture is creative. The artist does not "create" the pigments on his canvas, but the complete painting is essentially his own. The same is true of much of the work in operating engineering. Conversation with individual engineers shows that an engineer's urge toward creativity is satisfied by this kind of appeal to his originality and ingenuity, as well as his desire to achieve a magnum opus.

Design itself occupies a great amount of an operating engineer's time. At least a third of his work would come under this classification. The ingenious solution of design puzzles requires, of course, a consistently heavy background of formal education. In addition to design, some research and development must go into every specific project. Although pure research, as has been said, is at a minimum, about 15 per cent of the average operating engineer's working period must be spent in some field of pioneer development.

Thus far, there has been presented a description of the kind of services the operating engineer presents to his community. He obviously must have, as part of his inherent abilities, a leaning toward administration in order to co-ordinate the various activities within his field, as well as a certain patience to enable him to cover completely the wide variety of problems that he will encounter. In addition, it is essential that he retain a good portion of the imaginativeness of his youth. This engineer finds it necessary to work constantly with people, as well as with things. Inasmuch as the success of any operation depends in the last analysis on the individuals involved, and since comparatively few of the personnel of an operating company are engineers, the project engineer in operation must never lose sight of the human factor.

ENGINEERING EDUCATION

With these generalities established, what does the individual engineer think of the undergraduate education he has received? The spot survey showed desires with which we are all familiar. Of those surveyed, 20 per cent wished they had had more advanced technical studies, including mathematics, symmetrical components, tensor analysis, etc. A similar number, surprisingly enough, wished that they had had more education in actual engineering application. If I may interject a personal opinion here, I should like to hazard a guess that this kind of education is not possible in the colleges because it

involves becoming familiar with a great variety of specific electrical and electronic practices. Another 20 per cent felt that they would have done better had they had more formal training in economics and accounting. Perhaps a quarter of them felt the lack of sufficient training in the humanities; specifically mentioned were composition and writing, psychology and human relations, and general cultural subjects. The remainder of the items, mentioned as being lacking, were scattered. It must be pointed out, however, that 10 per cent of those interviewed said that they would have made no changes in the courses taken.

In pursuing further this apparent desire for additional undergraduate education, it was determined that over one half of those interviewed would not have deleted any subjects which they had taken. A reasonable conclusion drawn from this statement would be to say that engineering courses in colleges should be extended to cover a greater number of years or that formal education must be continued after achievement of the first degree. Considering the subject still further, those who recommended the deletion of subjects which they had when they were in college were asked to designate those courses which they would be apt to drop first. The answers to this portion of the survey were not at all conclusive. Half of those interviewed would have deleted engineering subjects; the other half would have omitted liberal arts subjects.

ENGINEERING CAPABILITY

THIS IS THE PICTURE of what the working engineer desires in engineering education, at least as the situation stood in one group of engineers interviewed recently. While not at all conclusive, it is quite apparent that greater breadth and depth of formal education are desired.

I should now like to testify to what I, as one engineer, would like from the people who work for me. I have been a "straw boss" of engineers for most of my working life and feel that, in this case at least, I know whereof I speak. I am impressed by the engineering capability found among all groups and ages of the formally educated. I am depressed, however, by the inability of most of the engineers to communicate good and ingenious ideas among ourselves.

An engineer in conference with his pencil and pad of paper seems to be able to interpret his ideas into one-line diagrams and similar drawings with astonishing accuracy and rapidity. The same engineer, when he is confronted with the necessity of wrapping up his ideas into a one-page memorandum for the quick transmittal of information to his associates, seems to become either halting or verbose. The quickness of his handling of a picture of an electric circuit is obscured by his use of words when he begins to write it up. Give me an engineer whose pen is as mighty as his slide rule.

Transducer for Measuring Rocket Thrust

The largest *SR-4*-type force transducer ever built by Baldwin-Lima-Hamilton Corporation for measuring both tension and compression loads was calibrated recently in its Cambridge, Mass., plant.

This specially built *SR-4*-type load cell of 250,000-pound capacity, 22 inches high and 12 inches in diameter, will be used by an aircraft company to measure rocket thrust. An unusual feature is two independent load-measuring resistance-wire strain-gauge bridge circuits for instrumentation.

This feature offers four advantages and alternatives: (1) simultaneous use of remote and nearby measurements, (2) use of two different types of instruments simultaneously to give oscillographic records and conventional indication, (3) standby circuit in the event of improper performance of one circuit, and (4) a means of resolving forces and moments in one plane by adding cell outputs from one bridge to obtain total force and subtracting cell outputs from the other bridge to obtain moments.

For calibration, right, Baldwin engineers applied test loads hydraulically through a much smaller precision-type *SR-4* load cell of 250,000-pound capacity, designed for compression loads only. This accurate cell was calibrated by the National Bureau of Standards. After calibration of the new cell with the *SR-4* strain indicator, forces can be measured with an accuracy within 0.1 per cent. Tension load calibration was accomplished on this machine in a similar manner.

Characteristics of Smooth Bundled Conductors

C. J. MILLER, JR.
MEMBER AIEE

POWER TRANSMISSION at 330 kv is now an accomplished fact in the United States and it seems quite likely that still higher voltage lines may be needed in the near future. Although several of the present 330-kv lines use a single 1.75-inch diameter conductor, it is anticipated higher voltage lines may be built with bundled conductors.

A rather extensive laboratory investigation into the corona and radio-interference characteristics of bundled conductors has been started, and the results indicate that it may be possible to predict these characteristics with fair accuracy.

So far, the investigation has been limited to bundles in which the conductors are smooth tubes, free from surface defects. It is realized that these results are higher than those which would be obtained for equivalent bundles using stranded conductors. However, these results will provide a yardstick with which to evaluate the performance of actual bundles, as well as supply a means for comparing the merits of different configurations without the necessity of a multitude of laboratory tests. Additional work yet to be done includes a study of stranding factors, the effect which may be produced by surface defects or contamination, and the benefits which may accrue from weathering.

The investigations were carried out in the high-voltage laboratory of the Ohio Brass Company at Barberton, Ohio. Tests were made on smooth conductors, both singly and in bundles of two, three, and four. All conductors tested were 25 feet long. Bundles were supported horizontally about 12 feet above the floor, which served as a ground plane. All of the high-voltage hardware and insulator strings were so shielded as to prevent the formation of visual corona up to 400 kv line-to-ground.

All radio-influence-voltage (RIV) measurements were made with a Ferris Model *32B* radio noise meter coupled to the bundle under test by means of the standard National Electrical Manufacturers Association (NEMA) circuit. The background noise for this circuit did not exceed 50 microvolts at 400 kv line-to-ground.

All corona observations were made in the darkened laboratory with descending voltage. The visual corona voltage is that voltage at which all visible light disappears from the bundle. Care was taken in each test to insure that each conductor of the bundle was free from surface defects which might lower its visual corona voltage. Following the corona-voltage observations, RIV measurements were made up to 400 kv line-to-ground.

The maximum surface gradient existing on each test conductor or bundle at the visual corona voltage has been computed and plotted in Fig. 1. Also included are points and a curve calculated from an equation presented many years ago by Peek.[1] The abscissa of the plotted test point for each bundled conductor is the "equivalent" conductor diameter, which is defined as the diameter of that single conductor which has the same maximum surface gradient as the bundle under consideration. The correlation between the recent tests and Peek's early work seems rather interesting, especially when one considers that his tests were made on parallel smooth conductors of less than $^1/_8$-inch diameter separated by a matter of inches, whereas the recent tests were made on much larger diameter single smooth conductors or bundles 12 feet from ground or 24 feet from their images.

The results of the analysis of the RIV tests indicate that the 100-microvolt level occurs at a voltage approximately 1 per cent higher than the visual corona voltage, while the 1,000-microvolt level lies about 4 per cent higher than it.

To predict the visual corona voltage of a given smooth bundle the procedure is as follows: (1) compute the maximum unit surface gradient for the bundle, (2) compute the bundle's equivalent diameter using the maximum unit surface gradient of step 1, (3) determine from Fig. 1 the visual corona surface gradient corresponding to the equivalent diameter of step 2, and (4) calculate the visual corona voltage by dividing the visual corona surface gradient from step 3 by the maximum unit surface gradient from step 1.

The 100- and 1,000-microvolt levels of RIV may then be predicted by multiplying the visual corona voltage by 1.01 and 1.04, respectively.

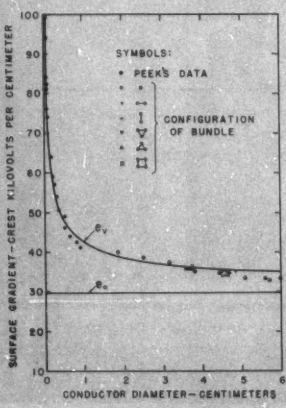


Fig. 1. Visual corona surface gradients of bundled conductors using Peek's data. *Parallel conductors range from 0.004 to 0.365 inch diameter with a few inches separation; other single conductor and bundles, 12 feet above ground or 24 feet from their images. The curve* $e_v = 29.8\ (1 + 0.301/\sqrt{r})$ *crest kv per cm, which relates the visual corona surface gradient* e_v *of a conductor with its radius* r. $e_o = 29.8$ *crest kv per cm is breakdown gradient for a uniform field in air at standard conditions.*

REFERENCE

1. Dielectric Phenomena in High Voltage Engineering (book), F. W. Peek, Jr. McGraw-Hill Book Company, Inc., New York, N. Y., 1929, pp. 52–8.

Digest of paper 56-520, "Mathematical Prediction of Radio and Corona Characteristics of Smooth Bundled Conductors," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Great Lakes District Meeting, Fort Wayne, Ind., April 16–18, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

C. J. Miller, Jr. is with The Ohio Brass Company, Barberton, Ohio.

Voltage Dips and Flicker

A. A. KRONEBERG
FELLOW AIEE

The voltage regulation problem in power systems has become more acute in the past few years, chiefly because of the critical constant-voltage requirements of modern automatic machines. Methods for alleviating some of these difficulties are outlined.

POWER SYSTEMS of electrical utilities are nominally constant-speed (mechanical) and constant-voltage (electrical) types of systems. Therefore, the degree to which these two quantities are maintained constant at all times determines the quality of service supplied by the utility. Changes in mechanical torques and in electrical currents on the system cause deviations from normal speed and voltage. Adjustments in input to prime movers, in excitation of synchronous machines, and in ratio of transformation are required to restore balance on the system with normal speed and voltage. Large capital investments are made by the utilities for equipment designed for automatic control of speed and voltage. All such equipment has an inherent time-delay characteristic. First, a deviation from normal value must take place before the need for correction is detected by the regulating device. Then, the corrective action must be damped or delayed enough to prevent oscillations. The magnitude of the controlled quantity is held within a band between a minimum and a maximum value for relatively slow changes of loading.

Sudden changes in current or torque will cause deviation from normal in voltage or speed outside the bandwidth of normal regulation before a correction can be made to bring it back within the band. A voltage dip is an occasional single disturbance caused by short circuits, faults, and starting inrush of current to motors. Voltage flicker is a series of recurring voltage dips. Cyclic or rapidly recurring voltage changes are generally more objectionable than noncyclic.

LIMITS OF TOLERANCE

VOLTAGE DIPS caused few complaints as late as two or three years ago. The emphasis on automation and the assumption by manufacturers of automatic machines, control contactors, and relays, of an absolutely continuous power supply have resulted in increased complaints from customers concerning troubles resulting from voltage dips or momentary interruptions. Requests by industrial customers for voltage regulation to plus or minus 3/4 of a volt, and for deviations from normal voltage for not longer than one cycle have been reported. Such limits are not practical today. No limits of tolerance can be assigned to voltage dips caused by uncontrollable transients such as short circuits and faults. Limitation of voltage dips from controllable causes to from 2 to 6 volts (120-volt basis) is a matter of judgment depending on the frequency of occurrence and the class of service affected by the dips.

The permissible amount of flicker voltage cannot be stated concisely for a number of reasons. The voltage flicker is objectionable primarily because of the reaction of the human eye to variations in electric light intensity. The reaction of individuals varies over a wide range. Flicker objectionable to one may not even be perceptible to another. Lamps of different size and type produce unlike light flicker from the same voltage flicker. The magnitude of the voltage change, the rate of change, the duration of the change, and the frequency of occurrence of the flicker all have an effect on the limit of flicker tolerance.

Numerous investigators have studied the flicker problem. The most complete analysis is found in a report prepared by Utilities Coordinated Research, Inc.[1] Fig. 1 presents a chart generally accepted as the result of a compromise of allowable limits set up by various authorities for their own use. The most irritating light flicker is in the order of six dips a second.

CAUSES OF DIPS AND FLICKER

SHORT CIRCUITS AND FAULTS are unavoidable operational hazards on a central station system. They produce voltage dips on supply busses of substations proportional to the ratio of the current delivered to the short circuit from the supply bus and the current in a short circuit occurring on the supply bus itself. The duration of such dips is the combined relay and circuit-breaker time required to remove the faulted equipment from the system. Even the fastest and most modern relays and breakers have combined times in excess of 3 cycles. Many relatively new relays and breakers, which a utility cannot afford to retire, have combined times of 20 cycles or more for short circuits causing voltage dips of 30 per cent on the supply bus. From an economic standpoint alone it will be many years before the duration of voltage dips can be reduced materially.

Cases of voltage flicker originating on the power system itself are extremely rare and, when detected, are eliminated without delay. Most of the flicker on central station systems is due to the customer's utilization equipment. The most common voltage problems are caused by the starting of motors. For reasons of cost, efficiency, and reliability, motors are designed to require a momentary starting current several times their full load running current in order to

Full text of paper 56-637, recommended by the AIEE Committees on Industrial Power Systems and Mining and Metal Industry, and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

A. A. Kroneberg is with Southern California Edison Company, Los Angeles, Calif.

produce sufficient starting torque. For approximate calculations, a starting current of six times normal at 35 per cent power factor may be used, but specific data should always be used when available. Motor-driven reciprocating loads such as compressors produce cyclic pulsation of voltage. Comparatively small variations of voltage may be objectionable if the pulsation occurs from 6 to 12 times per second.

Electric welders represent a class of equipment of great importance in power system flicker. Most welders have a smaller "on" period than "off" period and, consequently, have a low load factor. Fortunately, most welders are located in factories, where other processes require a large amount of power, and where the supply facilities are sufficiently heavy, so that no flicker trouble is experienced. In isolated cases, the welder may be the major load in the area, and serious flicker may be imposed on the distribution system which otherwise may be adequate for ordinary loads.

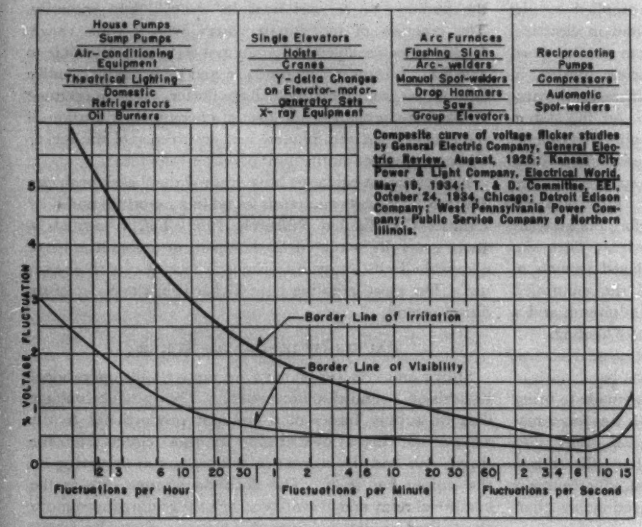


Fig. 1. Relations of voltage fluctuations to frequency of their occurrence.

Of the three types of electric furnaces, resistance, induction, and arc, the latter frequently causes voltage flicker. The operation of an arc furnace has two periods, the melting-down period, and the refining period. During the melting-down period, pieces of scrap will from time to time, at random, bridge the electrodes, approximating a short circuit on the secondary side of the furnace transformer. Consequently, the melting-down period is characterized by violent fluctuations of current at low power factor. After the steel has been melted down, a stable arc can be maintained on all electrodes by automatic electrode regulators. The refining period is characterized by a steady load of high power factor. The utility's concern is, therefore, confined to the melting-down period of the arc furnace operation and the voltage flicker produced during this period. This problem has received considerable study by utilities supplying service to arc furnaces. It has been recognized by the AIEE Committee on System Engineering, and a working group on arc furnaces has been established to develop a guide for application of arc furnaces on power systems. The curves in Fig. 2 express the substance of the working group's preliminary recommendations. It is a zone chart indicating the effect of connecting an arc furnace of a given megavolt-ampere rating of its transformer to a supply bus of a known short-circuit capacity. No objectionable flicker will be produced on busses with short-circuit capacity higher than shown by both curves, while objectionable flicker is to be expected on busses with short-circuit capacity lower than the two curves. Short-circuit capacity lying between the two curves indicates marginal conditions where objectionable flicker may occur from time to time and complaints from other customers of the utility may or may not compel the application of corrective measures.

The use of large continuous rolling mills for producing wide metal strip introduced new problems of speed and voltage regulation on utility systems. The loads, unless supplied through rectifiers, do not necessarily produce flicker in the sense discussed here. The load comes on and drops off in steps as the metal enters and leaves the rolls. The demand builds up in steps to full value in a few seconds, remains at full value for a longer period, then drops to almost zero in a few seconds. Whether or not a flicker takes place during this operation, there is a voltage swing during the cycle of the rolling mill, resulting in an excessive operation of voltage regulating equipment. When it is large enough, a cycling load of this nature produces phase-angle swings on the power system akin to the old problem of hunting.

PREVENTION AND CURE

THE FOREGOING briefly outlines the problems of voltage dips and flicker facing the utility engineers. As in matters of health and human relations, it is infinitely better to prevent the occurrence of trouble rather than to cure it after it has occurred. To do so it is essential that industrial engineers designing the customer's plant and utility engineers planning the system extension to serve the customer

have a complete understanding of each other's problems. The utility engineers must protect other customers supplied from their system against voltage dips and flicker in excess of the limits of tolerance yet they must do so at the lowest possible cost. They need to know the magnitude and duration of transient demands of the load to be supplied and methods of reducing them that may be available to the customer at a reasonable cost.

Since the magnitude of the voltage disturbance is measured by the ratio of the current causing the disturbance to the short-circuit current on the bus where the disturbance is observed, the obvious and fundamental solution would be to supply the customer from a bus having a sufficiently large short-circuit capacity to hold the ratio of currents within the limits of tolerance. The elements to be considered by the utility engineer are as follows: (1) detailed knowledge of the electrical characteristics of the customer's load; (2) limit of tolerance of voltage dip and flicker for this load; and (3) short-circuit capacity of substation busses within economic transmission distance from the customer's plant. Knowing the magnitude of current disturbances produced by the customer's equipment and the limit of tolerance of the corresponding voltage dips and flicker, the utility engineer can estimate the minimum short-circuit capacity of the required supply bus. He can then select the nearest substation bus having a short-circuit capacity in excess of the required minimum. Such a solution will result in satisfactory service to all concerned.

All too often, however, the solution is not as simple as outlined above. Adequate information on operating characteristics of the customer's equipment is not always available or is grossly underestimated. Equipment that is potentially disturbing to the utility system is at times added in an existing customer plant which had caused no disturbances up to that time. There may not be a substation bus of adequate short-circuit capacity within reasonable transmission distance of the customer's plant. In such cases it becomes necessary for the utility engineers to call upon the industrial engineers for a joint study of remedial measures directed toward the reduction of the magnitude of disturbing currents and the reduction of their rate of change. In some cases, industrial engineers may be able to minimize voltage dips and flicker by controlling manufacturing processes. Voltage dips caused by starting motors across the line may be reduced by the use of starters which limit the inrush of starting current and prolong the starting time. Intermittent 3-phase and single-phase loads may be supplied through motor-generator sets and flywheels may successfully and economically reduce disturbances caused by motor-driven reciprocating or intermittent loads.

Should the remedial measures under study fail to reduce disturbances to a satisfactory level or prove to be uneconomical, it would then be necessary for the utility engineers either to "stiffen" the system to the supply bus or run a separate transmission line to the customer from the remote bus of high short-circuit capacity. The difficulties in solving the problems of this kind are very seldom technical in nature. It is usually the determination of the equitable division of the extra cost required for supplying power to disturbing loads that necessitates prolonged negotiations.

CONCLUSIONS

SUMMING UP the utility's problem of voltage dips and flicker with specific reference to industrial customers, the following conclusions are submitted:

1. Designers of industrial control systems and automatic machines should not assume continuous and constant voltage supply from the utility system. Utility engineers must tell the customers that while every effort is being made to minimize voltage dips, these dips cannot be eliminated.
2. When given complete information on the electrical characteristics of a prospective new load, and its ultimate size, planning engineers of the utility system will provide an adequate extension of their system to serve the customer and to prevent disturbances to other customers.
3. Ignorance or misinformation regarding transient or cyclic performance of customer equipment may result in voltage dips or flickers on the utility's distribution system disturbing to other customers and which would, therefore, require correction. At best, the determination of the equitable shares of cost of correcting these disturbances is difficult.

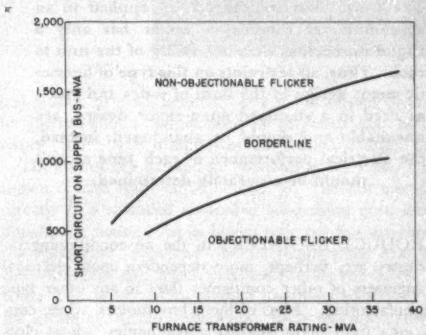


Fig. 2. Effect of electric arc furnaces on the voltage of the supply bus.

Mutual understanding by industrial and utility engineers of each other's problems should go a long way toward improved service to all concerned.

REFERENCES

1. The Visual Perception and Tolerance of Flicker. Utilities Coordinated Research, Inc., New York, N. Y., 1937.
2. Distribution Data Book. General Electric Company, *GET-1008D*, New York, N. Y., July 1951.
3. Large Electric Arc Furnaces—Performance and Power Supply, **B. M. Jones, C. M. Stearns.** AIEE *Transactions*, vol. 60, 1941, pp. 763–9.
4. Arc Furnace Loads on Long Transmission Lines, **T. G. LeClair.** AIEE *Transactions*, vol. 59, 1940, pp. 234–9.
5. Voltage Dip and Automation, **C. E. Quick.** *Bulletin*, Edison Electric Institute, New York, N. Y., Oct. 1955.

What Is An Air-Conditioning Horsepower?

P. W. WYCKOFF

The word "horsepower" when applied to an air-conditioner compressor motor has only a vague connection with the ability of the unit to cool. Thus, all restraints on this type of hermetic motor design in the form of codes and rules, as used in a standard open-motor design, are unsuitable and should be abandoned; instead, the electrical performance of each type of unit should be accurately determined.

PRODUCT ENGINEERS in the air-conditioning industry are, perhaps, more dependent upon electrical engineers of other companies than in any other type of manufacturing. Most of them buy motors, wires, controls, etc., from many supplying companies, whose electrical engineers are considered part of the air-conditioning development staffs.

Product design is, also, greatly affected by electrical engineers associated with the utility companies throughout the United States. Regulations which they establish have a direct influence on sales plans of the air-conditioning industry. Electrical engineers working for Underwriters' Laboratories, and local and national code authorities have had an important voice in establishing safe standards for product and installation. This encourages the public to enjoy the advantages of air conditioning.

In 1954, about 75,000 complete home-cooling units in the 2- through 5-hp range were sold. In 1955, it will be 125,000 and by 1960, probably about 500,000 per year. A typical air conditioner to cool an entire house consumes the power of about 24 refrigerators. About 350 pounds of copper are needed in the utility system to supply one such unit with power. In the face of this increase in power-supply problems, resulting from the air-conditioning industry's products, it is comforting to see the aggressive and determined measures being taken by the various utilities to prepare for the business, which is sure to come.

Fig. 1. Electrical components from a year-round home air conditioner.

As a further indication of the dependence of this industry, consider Fig. 1. It shows the electrical components from a typical year-round home air conditioner. It does not show wiring, etc., used in installation. These motors, controls, switches, wires, etc., account for almost one third the cost of the complete air-conditioning equipment. They have a determining effect on sales volume, service costs, and product reliability.

CODES AND STANDARDS

SOME OF THE CODES AND STANDARDS designed primarily by electrical engineers, which profoundly influence product design, are: Underwriters' Laboratories Standards, National Electrical Manufacturers Association (NEMA) Motor and Control Standards, The National Electrical Code, utility regulations, and local codes. Although to the air-conditioning designer, the codes and standards seem at times to be annoying kibitzers, no one would curtail the fundamental services they render the buying public. They will also be supported over the long term by the air-conditioning industry, if soundly based on consideration of safety and fairness. Purely arbitrary restraints will be rolled aside by the rising tide of customer demand.

This article deals with single-phase residential air conditioners. In an elementary way, compressor-motor horsepower will be discussed, which figures prominently not only in the design of motors and controls for home air conditioners, but also in the provisions of many codes. Because the same motor components will give vastly different performance if they are used in a compressor than in a standard open motor, much confusion has resulted. Horsepower, as a technical unit of energy consumption, has a simple clear meaning: 33,000 foot-pounds per minute. As a description of a standard open motor, it is a little less clear—a 3-hp standard motor is one which will deliver up to about 3.45 hp. As a description of hermetic compressor motor, it is so vague, air-conditioning engineers are frequently asked, "What is an air-conditioning horsepower?" The situation has not been helped any by people in the industry who advertise more cooling for the same money by trick use of the word

Full text of a paper presented at the Application of Motors to Space Heating and Cooling Conference, St. Louis, Mo., October 19–20, 1955 and recommended for publication by the Committee on Rotating Machinery.

P. W. Wyckoff is with the Chrysler Corporation, Dayton, Ohio.

"horsepower," which has only the vaguest connection with ability of the unit to cool. The horsepower of the compressor motor: nominal, actual, or fancied—high or low—is of no benefit to the customer. He is buying cooling capacity.

The following phases will be discussed:

1. A simple explanation of the refrigerant circuit and operating conditions of a typical year-round residential air conditioner.

2. Factors affecting the horsepower an air-conditioning compressor must furnish, and reasons why the home air-conditioner market must have compressor motors custom-built to its needs.

3. Bad results arising from the attempt to force these custom motors to act like standard open motors by designing codes and rules for them around old open-motor practices.

It is recommended that the entire practice of setting up code provisions and starting-current limitations in certain steps, corresponding to open-motor performance, be abandoned. Engineers should work together to show accurately the air conditioner's electrical characteristics on its name plate to guide the installer and the utility. These should include starting current and a high normal current carefully defined by joint industry action. No penalty should be attached to an air conditioner, because the figures on its name plate do not correspond to figures in a table. This procedure will permit putting all the engineering facts on the table, yet completely meet the needs of the air-conditioning field.

TYPICAL SYSTEM

A TYPICAL YEAR-ROUND SYSTEM for heating and air conditioning a home is shown in Fig. 2. It has four main elements: a forced-air furnace, a cooling coil mounted above the furnace, a waterless condensing unit containing most of the refrigerant machinery and located outdoors, and a year-round thermostat which maintains the desired temperature winter and summer—automatically operating the furnace or an air conditioner, as needed. This system requires little floor space in the home, uses no water whatever, and is quiet and economical in operation. This basic type will meet the bulk of the market requirements for some years to come. The electrical components previously shown in Fig. 1 are parts of this equipment.

Fig. 3 is a refrigerant circuit diagram for a typical home air conditioner. In this circuit, the compressor with its electric motor is a pump, which pumps refrigerant gas from a low pressure and temperature (about 40 F, as it returns from the cooling coil) to a higher pressure and temperature (about 180 to 250 F).

The hot gas leaving the compressor contains all the heat removed from the cooled space, plus the heat of compression. This heat can be discarded in several ways, but two methods are commonly used. In the method shown in the left circle, the hot gas is led into a condenser and cooled by a water coil. The heated water is then led to an outside cooling tower, where it is sprayed past moving air and cooled before being recirculated to the condenser. This method has the advantage of giving a somewhat lower pressure for the compressor to work against. But it has serious problems for the residential market, such as corrosion and maintenance, filling and draining as the seasons change, etc.

Fig. 2. Year-round system for heating and air conditioning.

The other main method for disposing of condenser heat is shown on the right circle of Fig. 3. The hot gas is led directly to a so-called air-cooled condensing unit, located outside the house. Air is blown over the fins attached to the refrigerant tubes and directly removes the heat from the refrigerant gas, which condenses inside the tubes. No water is involved. This method has many customer benefits including, in our experience, lower seasonal operating cost, so that it is rapidly replacing the tower method. It will be the standard method within a year or so, and the rest of this article is based on that assumption (Fig. 2).

After heat is removed from the refrigerant gas, thus condensing it, it is led as a liquid at 100 to 145 F to an expansion valve, where it is dropped in pressure to the low side pressure, partially flashing into gas, as it does so. The mixture of liquid and gas then passes through the tubes of the cooling coil; gradually evaporating completely into gas as it absorbs heat from the house air stream, which is blown by the furnace blower past the outer surfaces of the coil. The 40 to 50 F gas then returns to the compressor to complete the cycle.

LIMITING FACTORS

THE PRESSURES at the inlet and discharge of the compressor are determined within rather narrow limits by the

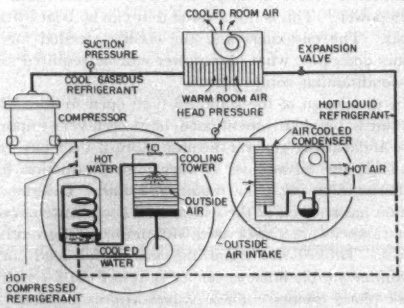
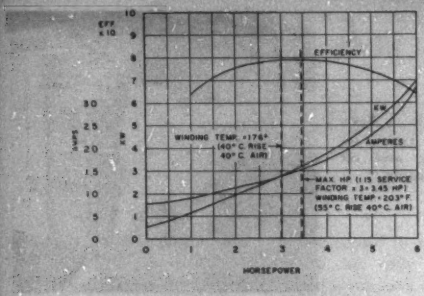
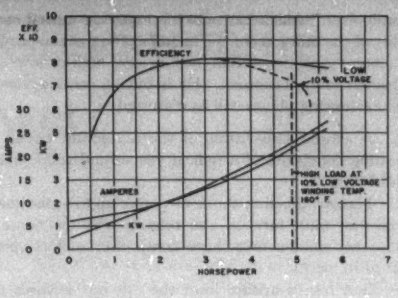
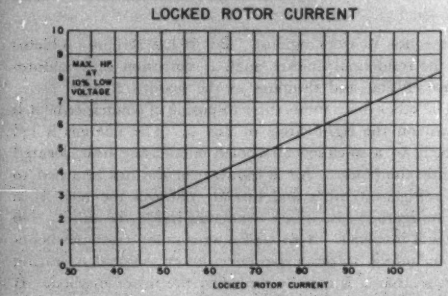


Fig. 3. Refrigerant circuit diagram for home air conditioner.







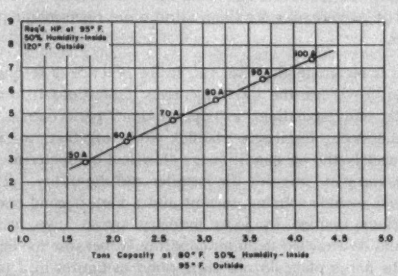


Fig. 4 (top left). Performance curves for a 3-hp single-phase 230-volt general-purpose open motor. Fig. 5 (top right). Performance curves for a 3-hp single-phase 230-volt hermetic compressor motor. Fig. 6 (lower left). Maximum horsepower a motor can supply for a given starting current. Fig. 7 (lower right). Maximum horsepower required for rated cooling capacity.

comfort conditions maintained inside the house and by the weather outside. If the temperature of the air in the house and passing over the cooling coil is 76 F and 50-per-cent relative humidity, a typical condition, the suction temperature will be around 40 to 50 F. Similarly, outside temperature determines discharge pressure. The other factor, besides the suction and discharge pressures, which determines the horsepower required to drive the compressor, is its displacement—the volume of gas pumped. This value is directly determined by the cooling capacity of the air conditioner—more cooling, more displacement, and more horsepower. This is not a game that can be beat by design tricks. The customers and the cooling needed for their homes determine what horsepower will be required for the air-conditioning compressor.

In the design of the standard-type open motor, NEMA standards, previously mentioned, have been very important. By standardizing general-purpose motors, they have made available the advantages of very high production to the customer using only a few motors at a time. This standardization has resulted in the widespread acceptance of certain performance values associated with motors of a given horsepower. Table I shows starting current, full-load current, maximum usable horsepower for standard 2-, 3-, and 5-hp single-phase motors. These values appear in many local and national codes and are used for selecting wire sizes, starting equipment, and other components.

Fig. 4 shows the performance curves for a 3-hp single-phase general-purpose open motor. Air is the cooling medium. The winding temperature at rated horsepower (176 in 104 F air) is defined by the standard. The maximum horsepower is limited to about 1.15 times the rated horsepower by the standard and by the fact that winding temperatures rise too high for good life beyond this load. The performance of one make of open-type motor built to the NEMA standard is very like that of another. The maximum usable horsepower of a 3-hp single-phase motor is about 3.45 hp.

Winding temperature is not a limiting factor for a motor used in a hermetic refrigerant system where the cool returning gas flows over the windings. If a rotor and stator, similar to those used in a standard open motor, are inserted in a hermetic compressor, they can be loaded almost to the breakdown point without high winding temperatures. Fig. 5 shows typical performance curves for 3-hp single-phase hermetic motor. A motor that would be called a 3-hp open motor can in a compressor easily carry 4.9 hp.

COMPARISONS

Table II compares certain performance characteristics of a 3-hp open motor with a hermetic motor. Differences in service factor, maximum horsepower, name-plate current, and starting current are obvious. Is there any doubt that the term "3-hp motor" is useless as a measurement of com-

Table I. Performance of Standard 2-, 3-, and 5-Hp Single-Phase Motors

Nominal Horsepower	Service Factor	Maximum Horsepower	Nameplate Amperes	Starting Current, Amperes
2	1.2	2.4	12	50
3	1.15	3.45	17	70
5	1.15	5.75	28	100

Table III. Corresponding Horsepower for Rated Capacity

Unit	Rated cooling capacity, Tons	Needed starting current, Amperes	Corresponding NEMA Horsepower
A	2.65	70	3
B	2.75	72	None (3.1?)
C	3.25	82	None (3.5?)
D	4.4	100	5

pressor power consumption or cooling capacity? This fact has been readily recognized by many electrical engineers familiar with our business. For this reason, the National Electrical Code now has separate sections covering hermetic compressor motors and it is not required to mark motor horsepower on the name plate.

From Table II, it can be noted that an important benefit from the higher loading of hermetic compressor motors is the lower ratio of starting to running current. This means more electrical revenue to the utilities for a given investment in the supply system.

Starting current is a factor associated with open motors which is also a definite limitation on hermetic motor performance. The maximum horsepower which can be taken from a single-phase motor is limited by starting current—even when starting torque requirements are low. A large part of the starting inrush is caused by the main winding. Fig. 6 shows the maximum horsepower which a typical compressor motor can supply for a given starting current. The effect of this is to limit the amount of cooling which can be supplied by an air conditioner, having a given starting current. This is explained in Fig. 7.

The cooling capacity of a home air conditioner is usually given at a standard condition of temperature and humidity: 80 F and 50-per-cent relative humidity inside, and 95 F and 40-per-cent outside. To be trouble-free anywhere in the United States market, it is also necessary that the unit operate continuously without tripping any of its overloads or safety devices at the following extreme load condition: 95 F, 50 per cent, inside; 120 F, outside; 10 per cent lower than rated voltage. This high-load condition determines the horsepower that must be available to drive the compressor. It is related to cooling capacity at the standard rating condition, as shown in Fig. 7. If a unit is to deliver 2.75 tons of cooling (1 ton = 12,000 Btu per hour), it will require about 4.9 hp at the highest load condition to drive the compressor. A 2.75-ton unit seems to fit the greater part of the residential market of homes in the 1,200 to 1,700 square foot class.

Superimposed on this curve are points taken from the previous starting current curve (Fig. 6). From Fig. 7, note the data, as given in Table III.

Assume a manufacturer finds the cooling capacity of unit *B* or *C* is needed by the home air-conditioning market and, also, wishes to abide by present starting current practice. Since no motor with 72- or 82-ampere inrush is listed in the tables, he would have to go to the 100-ampere level and pay for a 5-hp motor. In turn, the utility supply system would have to handle a 100-ampere inrush instead of 72 or 82. Yet the revenue from the electricity supplied would be little higher than from unit *A*. It is felt that the standardization of motor sizes, valuable in the open-motor field, is completely unsuited to air conditioning and benefits no one. Inasmuch as residential units are practically never used in multiple, they must have the cooling capacity to fit the typical home. Standardization on certain sizes has little to offer in this type of market—even from the standpoint of reducing cost.

Standardization of motor parts, which affect major tooling investments by motor manufacturers, is quite advantageous and does not standardize performance. Motor-lamination design standardization in rotor and stator, outside diameter, etc. is now widely used. Performance is varied by changing number of laminations (stacking length), amount of copper wire, etc. These changes greatly affect performance (2- and 3-hp motors commonly use the same laminations), but affect tooling cost to only a minor degree. This is the reason that standardizing performance in certain horsepower steps can promise little cost saving to the air-conditioning market. Practically all compressor motors for residential air conditioners are custom built for the individual unit.

Table II. Comparison of Performance of 3-Hp Open Motor with Hermetic Motor

Nominal Horsepower	Service Factor	Maximum Horsepower	Nameplate Amperes	Starting Current, Amperes	Starting Current, Amperes ÷ Running Current, Amperes
3 (Standard)	1.15	3.45	17	70	4.1
3 (Hermetic)	1.63	4.9	20.8	72	3.5

UNIT CAPACITY

IT IS NATURAL TO ASK, "Is it really necessary to have a motor capable of producing 4.9 hp in a residential air conditioner?" Actually, under a typical running condition in a home (usually a little milder than the standard rating condition), a 2.75-ton waterless unit will use only about 3.75 compressor hp, but compromising the ability of the unit to run under the heavier load of very hot days by failing to supply the needed motor horsepower is asking for trouble. Nothing infuriates customers more than loss of air conditioning when it is needed most. Then how about a unit, with less capacity, which does not need as much motor horsepower?

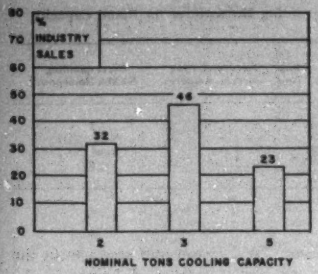


Fig. 8. Industrial sales vs tons cooling capacity.

Figs. 8 and 9 illustrate the capacity problem of the residential market. There are a large number of homes existing and being built in all sizes. Air conditioners will have to be built with the right cooling capacity for every important segment of this market. Fig. 9 shows what our industry has been producing up to the present. Our own company experience has been that a 2.75-ton unit is about right for the present market. It is felt that reducing this capacity, so that a 70-ampere inrush on the compressor can be attained, is pointless. It could also narrow the market for our air conditioners. Especially, at this time, each manufacturer must be free to meet the future market with units of any capacity he feels will be economical and saleable. All arbitrary restraints on motor-compressor design in the form of codes and rules based on a different industry--open-motors design—should be dropped.

SUMMARY

In summary, the following facts should be noted:

1. Much of the technical thinking behind many of the local and national codes, which affect the electrical design and installation of air conditioners, is based on characteristics of open-type air-cooled motors. These are greatly different from characteristics of hermetic motors, because refrigerant gas cooling removes winding temperature as an important factor.

2. The term "horsepower," as it implies a standard motor of fixed performance, is almost without meaning as applied to a hermetic application. A motor whose amount of iron and copper would make it a NEMA-standard 3-hp motor carrying not over 3.45 hp may carry from 2 to 5 hp when used in a refrigerant compressor.

3. The amount of horsepower, which must be provided by a compressor motor, is determined by the true cooling capacity of the unit, by the temperature maintained inside the house, and by the severest hot-weather condition under which the waterless air conditioner must run. Air conditioners will have to be built with the cooling capacity to meet every important segment of the home market, as well as have the ability to run in severe weather. The compressor motors required will not match open motors in performance details.

4. All codes, rules, etc., which affect home air conditioners and require them to have certain levels of starting current and horsepower, are unsuitable to this new market. They exist chiefly because they have proved useful in the open-motor industry. This type of restriction on air conditioning should be abandoned. Instead, all should work together to mark accurately the electrical performance of each unit on its name plate: starting current and running current at a high normal condition to be defined by joint industry action. This will give utility, installer, and inspector the information most needed. It will also meet the needs of the home air-conditioning industry.

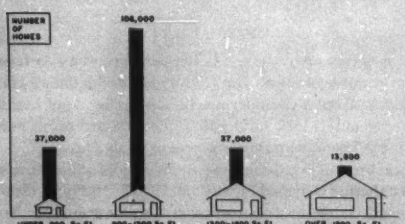


Fig. 9. Floor area of new homes constructed for first quarter of 1954.

Preserving Food by Radiation

Soldiers in the field may enjoy fresher and tastier food as a result of studies being made by Atomics International, a division of North American Aviation, Inc., Downey, Calif., under a U. S. Army Quartermaster Corps contract to determine the most practical means of preserving food by atomic radiation.

The studies, to be completed in a year, are concerned with four objectives of food irradiation: (1) reduction of field refrigeration by the use of radiation sterilization or pasteurization; (2) improvement in the quality of canned foods; (3) deinfestation of grain and dried solids, such as, powdered milk, oatmeal, etc.; and (4) irradiation of foods to prevent sprouting.

Although the studies are being made primarily from the standpoint of military economic and logistic feasibility, possible commercial applications are also being explored. Under the contract, the company is not seeking to develop new means of preserving foods by radiation, but is analyzing from an industrial standpoint methods already proposed.

The principal sources of radiation being considered for the food preservation study are electron accelerators, radioisotopes, used reactor fuel elements, direct nuclear reactor radiations, and radiation from reactor coolants.

Two research reactors now in construction by Atomics International are expected to be used for radiation preservation studies, although their primary purpose will be for other applications. These reactors are the medical research machine for the University of California at Los Angeles (Calif.) Medical Center, and an industrial research reactor for Armour Research Foundation, Chicago, Ill.

Conductor Vibration Damping

J. S. TOMPKINS
MEMBER AIEE

L. L. MERRILL

B. L. JONES
ASSOCIATE MEMBER AIEE

WIND-INDUCED VIBRATION of overhead conductors is inhibited by the use of Stockbridge dampers. Energy relationships are indicated by Fig. 1. Vibration amplitudes tend to increase until the rate of energy input from wind, Curve *A*, is balanced by the rate of mechanical-energy dissipation in vibration, Curve *B*. The function of dampers is to increase the total rate of dissipation, Curve *C*; so that equilibrium occurs at insignificant amplitudes. The best possible damping occurs when a damper can absorb vibration energy from the conductor at the maximum possible rate.

Using the familiar analogy between an idealized vibrating conductor and an electrically long open-end transmission line without losses, it has been shown that the application of a vibration damper near the suspension point of an overhead conductor is analogous to connecting a lumped impedance into a long electric line near the open end. The lumped impedance, plus the impedance of the "stub-end" of the line, constitutes a terminating impedance for the line. If this impedance is equal to the conjugate of the characteristic impedance of the line, the line would be properly terminated for maximum possible transfer of power. In the mechanical case, proper termination would constitute the maximum possible damping. The characteristic impedance of an idealized conductor, i.e., ratio of force to velocity, would be $Z=\sqrt{TW/g}$, where T is tension, W is weight per unit length, and g is acceleration by gravity.

Methods have been developed for using known damper and conductor characteristics to estimate relative damping effectiveness at any normal vibration frequency (Fig. 2). The dynamic characteristics of a Stockbridge damper are determined by vibrating the damper clamp at controlled amplitudes and frequencies and measuring the force and velocity and either the power dissipated in the damper or phase angle between force and velocity.

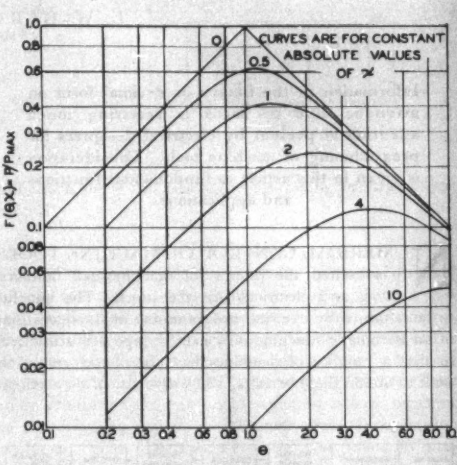


Fig. 2. Characteristics of idealized line. *θ=ratio of effective resistance of termination to characteristic resistance of line; χ=ratio of effective reactance of termination to characteristic resistance of line; P/P_{max}=ratio of power dissipated in termination to maximum possible power which can be transferred to the termination.*

It has been found that energy dissipated in a conductor vibrated in the laboratory can be determined approximately by measurement of inverse standing wave ratio at the driven end of the span. Estimates of relative effectiveness of dampers, as is shown in Fig. 2, have been checked by mounting the dampers on vibrating conductors in laboratory spans and measuring the inverse standing wave ratios of the conductors near the dampers. This ratio is approximately equal to the ratio of the actual rate of energy dissipation to the maximum rate which would be possible with proper termination of the span.

Data on energy input from wind and energy dissipation in conductors and dampers have been related, therefore it is possible to arrive at estimates of vibration amplitudes in spans exposed to wind. Such estimates have been checked by comparison with natural vibration of actual spans.

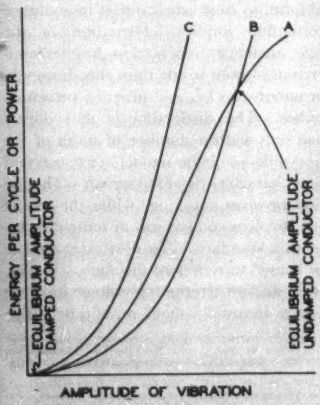


Fig. 1. Qualitative relationships, conductor vibration, constant frequency. *A—Energy input from wind; B—Vibration energy dissipation, undamped conductor; C—Vibration energy dissipation; same conductor with vibration damper added.*

Digest of paper 56-212, "Quantitative Relationships in Conductor Vibration Damping," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Systems and Apparatus*, 1956.

J. S. Tompkins is with Aluminum Company of America, Pittsburgh, Pa.; L. L. Merrill is with Stevens Institute of Technology, Hoboken, N. J.; B. L. Jones is with Jones-Hettelsater Company, Kansas City, Mo., and was formerly with Aluminum Company of America, Massena, N. Y

Some Basic Aspects of Numerical Machine-Tool Control

L. W. HERCHENROEDER
MEMBER AIEE

Information in the binary or decimal form on magnetic tape or cards is receiving much attention at present by electrical designers for programming of machine tools. Consideration is given in this article to fundamental functions and applications.

NUMERICAL CONTROL OF MACHINE TOOLS has excited the interest of machine-tool builders, users, and electrical manufacturers. The benefits to be obtained by external programming of the operations of an automatic machine on cards or tape are attractive, so that a number of machines have been and are being built to obtain these benefits. The diversity of these efforts have emphasized the need for a consideration of their fundamentals to provide a common basis for the discussion of physical systems.

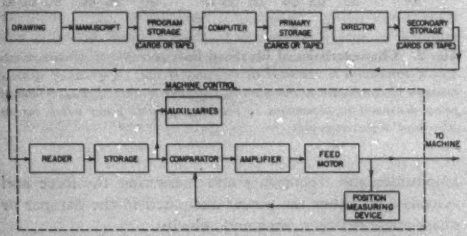


Fig. 1. Functional diagram showing relationship of components of a numerical control system.

NUMERICAL CONTROL SYSTEM

THE VARIOUS FUNCTIONS involved in the numerical control of a hypothetical machine tool are shown in the block diagram of Fig. 1. Many systems do not have all of the functions listed, and the functions may not be in the same relative locations. This will affect the apparatus physically, but is not important for the consideration of the basic aspects of numerical control. Usually, though not necessarily, a drawing of the part to be produced will represent the starting point for development of the program. From this drawing, the next step is to prepare a manuscript containing a detailed description of all machine operations necessary to make the part. This description will include such items as the tooling to be used, distances to be moved, feeds, speeds, and auxiliary operations. Information on the manuscript is then transferred to the program storage medium in the form of cards or tape, which for relatively simple systems may serve as the input to the machine controls. More complicated systems, such as those for contouring, usually require that the cards or tape be fed into a computer where the tool path, including cutter offset, is calculated and recorded in the primary storage medium. Interpolation is performed in the director, which generates the secondary storage medium as the input to the actual machine control, shown in dotted lines in Fig. 1. As part of the machine control, a reader is required to extract the information from the secondary storage medium. The data must be stored while being used by the control system; this storage may be accomplished by the reader itself or by internal storage in the machine control, according to the particular system.

SIGNAL CONVERSION

AT THIS POINT, position data is fed to the closed-loop systems controlling the machine motions. Since the actual machine motions are analogue in nature, while the data taken from the drawing is digital, a digital-to-analogue conversion must, therefore, take place at some point in the programming or in the control system. The exact point at which this conversion takes place will depend on the individual system. It may occur at the last possible point, at the machine motion itself, but in some systems, conversion is performed in the computer, so that the data in the secondary storage is analogue.

Numerical control implies the use of information in numerical or digital form, as contrasted to that in analogue form. Digital information implies information in the form of pulses, while analogue information implies continuity. The distinction is more subtle than this, however, since analogue information can be, and often is, presented in the form of pulses. The distinction is that digital signals are concerned only with a number of states of the signal—usually two—while analogue signals are concerned with the value of some characteristic of the signal. The use of digital information involves counting, while the use of analogue information involves comparison of some characteristic of the signal to a standard. To illustrate, assume that a voltage signal is used to represent distance. In Fig. 2, both a direct voltage and an alternating voltage indicate a measure of distance in terms of voltage amplitude. For

Full text of a paper presented before the 20th Annual Machine Tool Electrification Forum, Buffalo, N. Y., April 17–18, 1956, sponsored by Westinghouse Electric Corporation.

L. W. Herchenroeder is with Westinghouse Electric Corporation, East Pittsburgh, Pa.

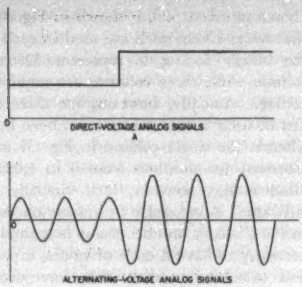


Fig. 2. Analogue signals as direct and alternating voltages.

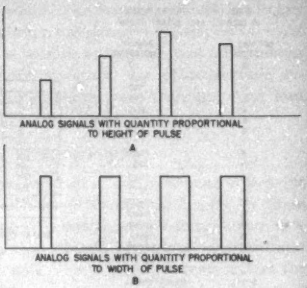

ANALOG SIGNALS WITH QUANTITY PROPORTIONAL TO HEIGHT OF PULSE
A
ANALOG SIGNALS WITH QUANTITY PROPORTIONAL TO WIDTH OF PULSE
B

Fig. 3. Analogue signals in the form of pulses.

the alternating voltage, distance could have been made proportional to frequency or phase. All three indications represent analogue signals. In Fig. 3, pulse signals, which are also analogue in nature, can be seen. In Fig. 3*a*, the quantity of distance is proportional to the height of the pulse and, in Fig. 3*b*, proportional to the width of the pulse.

Digital signals usually have two states. These states may be the presence or absence of a voltage or a voltage of one polarity as compared to a voltage of the opposite polarity. Within reasonable limits, the magnitude or shape of the voltage pulse is not critical; the permissible variation depends on the components used in the particular control system. The lack of sensitivity to reasonable variations in the signal is the basis for the high inherent accuracy of digital systems.

APPLICATIONS

From the application standpoint, numerical controls for machine tools can be divided into three groups, according to function of the machine; these are controls for positioning, straight cutting, and for contouring.

Positioning control, most simple of the three types, may be used for drilling and punching operations. In this type only, the end points of travel are of interest and overshoot may be tolerated. In general, it does not matter what path is taken between two holes, except that the path chosen may, of course, affect the time required for travel. And, a choice of path may be restricted by the necessity of avoiding obstructions.

The next order of complexity is represented by straight-cut control, such as would be used for the turning of a stepped shaft in a lathe. In this type, position of the tool must be controlled not only at the end points, but also at all points along the path of the cut. The feed rate must also be controlled and overshoot is not acceptable. More than one machine motion is usually required; however, when two or more motions are used at the same time, co-ordination between the position controls is not required.

Contouring control, the third group, requires the programming of any tool path that can be generated by the machine motions. Usually simultaneous position control of two axes is present, including control of the feed rate. The necessity for programming the feed motions in small steps, in order to follow arbitrary curves and the necessity to make correction for cutter offset, makes contouring control much more complex than positioning or straight-cut control.

POSITION DATA

From still another standpoint, numerical control systems may be classified as incremental or absolute systems, depending on how the position data is handled. Incremental systems specify a new position in terms of the distance and direction from the last position. Absolute systems specify each position in terms of the distance from some arbitrary base. In an incremental system, an error in programming a given position will affect all succeeding positions. With the absolute system, an error in programming is not passed on to succeeding positions. For incremental systems, power failure presents a problem in that the system may lose its memory of position, thus making it necessary to go back to some base point to pick up the program. However, the apparatus required for an incremental system is more simple and, therefore, has greater inherent economy and reliability than an absolute system.

CODING OF INFORMATION

Coding of numerical information, particularly in the primary storage medium, is currently receiving much attention from machine-tool builders. Drawings and other design data generally use decimal notation for all numbers except those numbers less than one, which are frequently expressed as fractions. However, fractions may be easily converted to decimals; there is a considerable trend toward use of decimal rather than fractional notations on drawings.

Since decimal numbers involve the use of ten digits, from 0 to 9; to represent these digits mechanically requires that the mechanism have 10 possible states. In desk-type calculators, this is accomplished with gears having 10 teeth, each of which represents one of the decimal digits. A

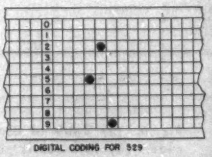


Fig. 4. A typical card or tape, punched to indicate the number 529 decimally.

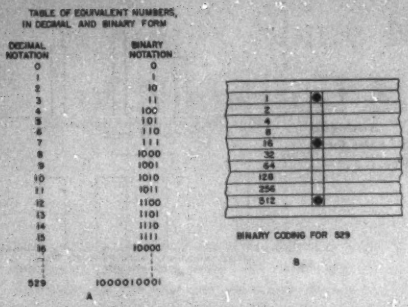


Fig. 5. (a) Table showing equivalent numbers in decimal and binary form. (b) Binary coding for the number 529.

comparable arrangement for punched cards or tape is to assign each of the decimal digits to 1 of 10 positions and to indicate a decimal digit by punching a hole at that precise position, as shown in Fig. 4. A comparable arrangement for indicating decimal digits on magnetic tape or cards would be based on magnetization in one direction as equivalent to a punched hole, and no magnetization (or magnetization in the opposite direction) as equivalent to no punched hole. This plan is one of those used with punched card equipment; it can also be used with punched tape when 10 or more rows are available. It has the advantage that the operator can easily tell what number has been punched, but also has a disadvantage in that it is inefficient in making use of the full information capacity of cards or tape and control equipment.

COMPARISON OF SYSTEMS

CARDS AND TAPE—as well as such control components as relays, electronic tubes, and magnetic and semiconductor devices—lend themselves readily to a two-state type of operation. This suggests the desirability of using numerical information in the binary rather than decimal form. In the binary system only two digits, 0 and 1, may be arranged to represent any particular number. Fig. 5*a* shows how identical numbers are expressed in both systems, binary and decimal. Binary coding for an arbitrarily chosen number, 529, is shown in Fig. 5*b*. It can be seen that while 10 channels are used in each of Figs. 4 and 5*b*, the binary coding to represent 529 requires only one column while three columns are required for the decimal coding. Actually, however, the three columns of Fig. 4 can be used to represent all numbers, from 0 through 999, whereas the single column in Fig. 5*b* has the capacity to represent the numbers from 0 to 1,023. As a practical disadvantage, however, it is virtually impossible for an individual to recognize by inspection the decimal equivalent of a binary number of any magnitude; in general, it is necessary to have a table of values, a pad and pencil, or a desk calculator to make this conversion. Further, when large numbers are involved, it is difficult to transcribe binary numbers without error, because of the monotony experienced when working with zeros and ones.

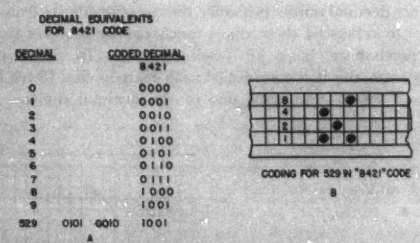


Fig. 6. (a) Table of decimal equivalents for the 8421 code. (b) How 529 is punched in 8421 code.

WEIGHTED DECIMAL CODES

AS A COMPROMISE between decimal and binary coding, coded decimal notation has most of the advantages of both and few of their disadvantages. In binary notation, the minimum number of binary digits that can be used to represent "10" is four. Accordingly, there is a first inclination to use the first 10 binary numbers. This is known as the *8421* code and is illustrated in Fig. 6. Note that binary representations for 10 to 15 are not used. For decimal numbers larger than nine, each of the decimal digits is represented by the proper combination of four binary digits, as illustrated for the number 529 in Fig. 6*a*. The *8421* code is weighted; that is, a definite decimal value is associated with the "ones" in each of the four positions. By adding the weights associated with the "ones" in a particular coded number, the decimal value can be obtained. Fig. 6*b* shows that the number 529 in the *8421* code requires four rows and three columns, for a total of 12 possible hole positions. This compares with 10 holes for the binary code in Fig. 5*b*, and 30 holes for the straight decimal code in Fig. 4. Thus, the economy of coded decimal notation approaches that of the straight binary code and considerably exceeds that of straight decimal notation. Further, the readability of weighted decimal codes is superior to that of the straight binary code and compares favorably with the straight decimal code. Decimal digits represented can be obtained easily by adding the weights associated with the holes. An added advantage is that operators quickly develop the ability to recognize on sight the value of the numbers represented.

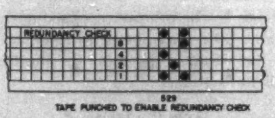


Fig. 7. Redundant information permits checking for errors. This tape is punched to give an odd number of holes in each column. An error will cause an even number of signals and bring about an indication that error is present.

The *8421* code is not the only code that can be used; in fact, there are over 70 million ways in which the 10 decimal digits can be represented by 4 binary digits. Even though only 17 of this 70 million are positive weighted codes, codes which are not weighted and those employing more than 4 binary digits are also of significance for numerical control. Among several decimal codes, the *2421* and "excess three" codes have the property of forming the nines complement by simple inversion; this is quite helpful in arithmetic operations. The biquinary code always has a "one" in one of the first two rows and a "one" in one of the last five rows. This characteristic is most useful for error checking.

Checking for errors is made possible through the inclusion of redundant information. For example, Fig. 7 shows the addition of a fifth row which is punched to insure that each column contains an odd number of holes. A single error will, therefore, result in an even number of signals per column. Through circuitry designed to register odd or even numbers of holes, it is possible to indicate that an error has been made. By more elaborate use of redundant information it is possible to check more than one error and actually to locate and correct errors.

THE FUTURE

AT PRESENT, many varieties of machine control systems have been built which have incorporated some of these basic ideas. The future is certain to see many other new applications of numerical control, of designs which cannot be fully anticipated now. However, it is certain that the many varieties—past, present, and future—will have a common origin in principles which are fundamental today in the numerical control of machine tools.

Automation and Machine-Control Gauging

W. C. MULLIN

Automatic and machine-control gauging, whereby badly machined parts can be either prevented or separated from the good pieces, contributes towards greater efficiency in the manufacturing process. Methods of gauging, as well as the recent utilization in production for maximum benefit, are discussed.

WHENEVER ENGINEERS, BUSINESSMEN, or any individuals set out to reach a goal, it frequently happens that some of the most difficult problems involve selecting the most desirable of several alternatives. Whether the objective is a distant city or the successful development of a new machine, there are many critical points along the way when alternatives must be evaluated.

To engineers who are directly concerned with machine tools, the most productive use of automatic gauging is an important objective. To obtain its maximum benefits, it is necessary to know the types of systems now available and to decide how each should be utilized; in other words, to select the form of automatic gauging that is best for a particular situation.

GAUGING METHODS

THE ENGINEER or company that is giving serious consideration to automatic or machine-control gauging is doing so only because it can contribute such definite tangible benefits, as lower costs, higher production, or greater efficiency. Regardless of their relative importance, attaining one or more of these benefits requires the evaluation of several factors.

Assuming, then, that automation gauging represents a worthwhile goal, how should one select a method to achieve it. For automation gauging, either what is called "in-process" gauging or, as an alternative, "post-process" gauging may be chosen. By in-process gauging it is simply meant that gauging the piece part or process is done as machining operations are being performed. By post-process gauging, gauging the part or process is done after operations are performed. The major difference between these methods is that in in-process gauging bad parts or scrap are prevented from being produced, and in post-process gauging, the bad parts are separated from the good, permitting good parts to continue in the process.

IN-PROCESS GAUGING

FIRST, consider in-process gauging. In this method, the gauging unit is ordinarily mounted directly on the machine in such a manner that it contacts the piece part while it is being made. The schematic diagram, Fig. 1,

Full text of a paper presented before the 20th Annual Machine Tool Electrification Forum, Buffalo, N. Y., April 17–18, 1956, sponsored by the Westinghouse Electric Corporation.

W. C. Mullin is with Pratt and Whitney Company, Inc., West Hartford, Conn.

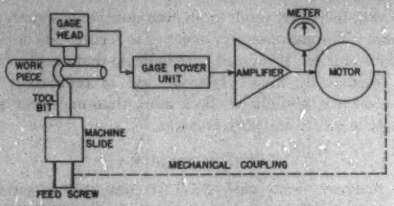


Fig. 1. Automatic in-process gauging system for applications, such as a boring machine or lathe.

purely hypothetical, shows a simplified application of automatic in-process gauging as applied to a lathe, grinder, or similar machine.

The gauge circuit, amplifier, and motor supply feedback to the cross slide of the machine that is determining the size of the piece being machined. If the workpiece should be large, for example, the amplifier would receive a voltage which would turn, through the motor, the feed screw until this voltage again became zero. The intelligence fed back continuously into the machine controls causes the machine to make parts that are within prescribed tolerances.

As a further example, let us take an outside-diameter (OD) grinder. By means of a C-type frame on the gauging fixture, which can be clamped directly onto the diameter of the part being ground, the control system can be set up so that the grinding wheel will traverse in at a fast feed until it gets within 0.003 inch of nominal size. At this point, the gauge will furnish its first signal to the machine and will cause the infeed of the grinding wheel to switch from fast feed to slow feed and continue infeeding. About 0.0001 inch from nominal size, the gauge furnishes a second impulse to stop the infeed of the grinding wheel and allow it to start to spark out. A third signal from the gauge will be furnished to the machine when the part comes to size. This impulse causes the machine to retract the grinding wheel; the part is as close to correct size as possible.

Another application of in-process gauging is an OD grinder, Fig. 2, that is set up to grind the bearing sections of a crankshaft. Machine control is used in conjunction with the gauge to produce on-gauge parts. Another added feature of the machine is the material-handling equipment, which takes the rough turned crankshaft from the conveyor and places it in the grinder. When the part is ground to size, it removes the finished part and places it in a second conveyor, which transports it to the next operation in line.

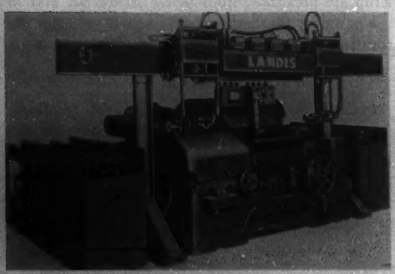
An ideal arrangement would be to have a series of machines in an integrated line, with each machine performing a particular operation. A gauge to monitor that particular operation might be at each of these machines and, thereby, prevent that machine from making bad parts. This would insure that the efficiency of the line would remain high and that only good parts would be transferred from one operation to the next. The major problem here, however, is the fact that "in-process" gauging as such is not applicable to all types of machining operations. Generally, it is most suitable for inside-diameter (ID) and OD grinding, ID and OD turning, and various types of surface or flat grinding.

An illustration of in-process gauging for flat grinding is a surface grinder, Fig. 3, on which the gauge is located to the left of the table with the control unit directly above the table. In this application, the gauging contact rides directly on the piece part as it is being flat ground. When grinding, the table moves to position the chuck halfway under the grinding wheel. Gauging equipment directs the speed and feed of the grinding wheel and then allows it to "spark out" until the product comes to size. In this instance, also, grinding is done to control limits.

POST-PROCESS GAUGING

To return to post-process gauging—the second alternative—there are two methods of machine control which are normally used. The first is similar to the method just discussed in that tooling on the machine is adjusted after each part is gauged and before the next is made. This is termed a continuous feedback control system.

A representative application is for the proportional control of a grinder, Fig. 4, in which it is not always practical to measure the workpiece as it is being sized. Instead, the part just ground is used to reset the machine for the following piece. The gauge measures the piece that was just sized by the position of the switch that stopped the grinder cycle. If this size is correct, no error voltage will be applied to the motor to reposition the switch. If, however, the size is incorrect, the motor will run in the appropriate direction to do two things: (1) find a new position on the slide-wire to reduce the error signal to zero, at which time action stops; and (2) reposition the switch which controls the feed stop on the machine.



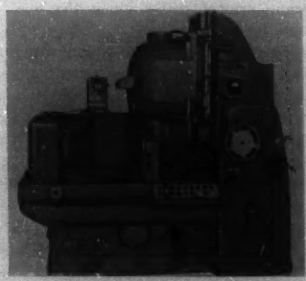


Fig. 2 (left). Grinding machine demonstrates in-process gauging with machine control. Fig. 3 (right). Surface grinding with in-process gauging and machine feedback control. The table holding the gauge and the magnetic chuck are in loading position.

As a concrete example of "post-process" gauging, Fig. 5, a two-spindle automatic is capable of turning both the ID and the OD of two parts simultaneously. With the transport mechanism that is incorporated, the chucks are loaded from the loading chutes and the cutting tools come in to cut the shoulders and the ID simultaneously. The transfer mechanism then removes the two parts from the chuck and places them in gauging position. As the cutting tools move in to cut the next new parts, the gauging spindles also come in to the two previously machined parts and check the various significant dimensions. Through the control unit at the right of the machine, the proper signals are fed back to solenoid-operated ratchet devices, which adjust the tooling by a preset amount. This adjustment brings parts back on size should the dimensions be incorrect.

The second method of control is what is normally referred to as zone control or precontrol and is tied in closely with the theory of quality control. In this system, the precontrol or control zones are set at something less than product tolerance; the machine control unit of the gauge is set up as is shown in Fig. 6. The center line represents the nominal size of the piece part and the two intermediate lines—one plus, the other minus—represent the precontrol zones. The two extreme outside lines define actual product tolerance.

In operation, each piece part is fed into the gauge as it is produced by the machine, and the gauge then measures the dimensions in question. If these dimensions fall within precontrol tolerance limits, no correction is necessary; the part is passed as a good part and the machine receives a signal to permit production of a second part. This sequence continues as long as all of the piece parts are falling within the two precontrol zones. If, however, two successive piece parts fall outside of the precontrol zones, either on the high side or the low side, then an impulse transmitted from the gauge to the machine produces an appropriate tooling correction to bring the part back within tolerance. Ordinarily, this will cause several piece parts to be made within the precontrol zone before a second correction is necessary. If, however, two successive parts fall outside of the extreme product tolerance limits, then the control ordinarily functions to shut down the machine and to signal an operator that human attention is needed.

The equipment in Fig. 7 is a typical post-process or in-the-chute type gauge. Basically, it is designed to measure round parts with holes in the center. As the part falls from the machine or grinder into the gauge, the gauge then inspects the hole for diameter and taper and sorts the parts as "good" or "bad." Control units used with this gauge are of the precontrol or zone-control type and will furnish an impulse back to the machine only when a part is out of either the precontrol or the end-limit zones of tolerance on the piece part.

Fig. 5. An application of post-process gauging with tool correction.

GAUGING SYSTEMS

BOTH in-process gauging systems and post-process systems perform very well on machine tools that are equipped to take the intelligence of the gauge and to control according to that signal.

If it is proposed to design and develop a complete process line, then it is likely that new machines will be employed. In this case, there will be no difficulty in obtaining machines that can be suitably equipped and operated with automatic controls. At present, virtually every machine-tool builder in this country is producing machines that are or can be equipped with automatic gauging.

On the other hand, if circumstances require that existing machines be utilized when automating or integrating a particular process, it will be necessary to consider whether these older machines are suitable for automatic gauging. If the machines are not capable of the very small increments of adjustment that are sometimes required, then it is foolish to spend money in the expectation that these machines can give high performance.

In such a case, it is generally more desirable to locate

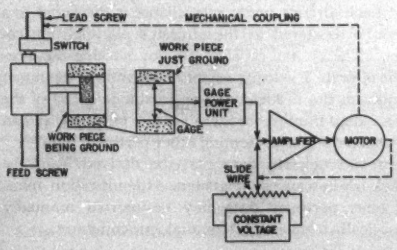


Fig. 4 (left). Post-process gauging, as applied to a grinder.

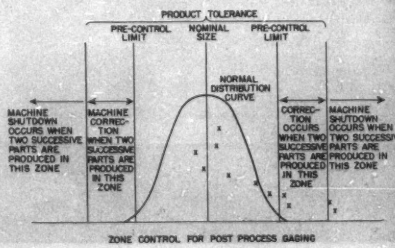

PRODUCT TOLERANCE
PRE-CONTROL LIMIT
NOMINAL SIZE
PRE-CONTROL LIMIT
NORMAL DISTRIBUTION CURVE
MACHINE SHUTDOWN OCCURS WHEN TWO SUCCESSIVE PARTS ARE PRODUCED IN THIS ZONE
MACHINE CORRECTION WHEN TWO SUCCESSIVE PARTS ARE PRODUCED IN THIS ZONE
CORRECTION OCCURS WHEN TWO SUCCESSIVE PARTS ARE PRODUCED IN THIS ZONE
MACHINE SHUTDOWN OCCURS WHEN TWO SUCCESSIVE PARTS ARE PRODUCED IN THIS ZONE
ZONE CONTROL FOR POST PROCESS GAGING

Fig. 6 (right). Relationship of probability curve to zone control.

Fig. 7. Post-process or in-the-chute gauge with feedback.

Fig. 8. A fully automatic inspection machine.

fixture-type gauges in the machine area so that the operator can periodically check the parts being made and can adjust the machine manually. Automatic inspection machines can be placed at the end of the line through which all piece parts will be passed. Such an inspection machine, Fig. 8, would sort out rejects and pass on good parts for further assembly or for shipment to the ultimate customer. This Sigmatic gauge is entirely automatic and is usually fed from a hopper. The parts are fed into gauging position and are gauged for several dimensions simultaneously. The parts are sorted for undersize, oversize, and good parts. Bad parts are rejected and good parts are ready for assembly.

In this general discussion of automatic and machine-control gauging, it has been impossible to consider fully the requirements of any particular application, or to specify what type of gauging should be chosen for a certain set of conditions. Certainty of choice is possible only when an entire array of engineering factors has been evaluated, however there are characteristics within the family of automatic gauging equipment which can serve as guide-posts to indicate how, when, and why automatic and machine control gauging can be used for best benefit.

Equipment Developed for Monitoring Air Traffic

A special cathode-ray tube display facility for presenting information pertaining to an aircraft traffic situation has been developed by Electronics Division, American Machine and Foundry Company, Boston, Mass., under contract to U. S. Army Signal Corps. Essentially, the equipment is the electronic equivalent of existing manually operated plotting boards.

The electronic display equipment basically is a plan-position indicator for a trace-while-scan surveillance radar system. Each aircraft under surveillance is displayed as a coded symbol centered at the aircraft's plan-position coordinates. The symbol consists of a dot marking the location of the aircraft, a velocity vector originating at the target dot to indicate the heading and approximate speed of the aircraft, a 3-digit number for identification purposes, and an array of coded dots for presenting other pertinent data.

Position and velocity data may be derived from the basic track-while-scan radar system. Identification number and other pertinent data may be inserted manually or automatically from a digital or analogue computer.

An Economic Study of High-Voltage Transmission

A. J. WOOD
ASSOCIATE MEMBER AIEE

J. M. HENDERSON
ASSOCIATE MEMBER AIEE

THE RESULTS OF A STUDY, made in the light of present-day costs, on the economics of high-voltage transmission are presented. The study considers technical and economic aspects of two transmission patterns: straightaway transmission for distances of 25 to 300 miles, and extra-high-voltage transmission superimposed on an existing 115- or 230-kv system. The costs used in the study are averaged values at 1954–55 price levels and include energy and capacity charges for losses, as well as investment charges for terminal equipment and line construction.

The system considered for the evaluation of straightaway transmission economics is illustrated in Fig. 1, which also shows the cost of energy transmission as a function of voltage for various transmission distances. The costs, shown for both single and dual conductor lines, apply for loadings in the economic range of each voltage level. Approximate minimum and maximum loadings in the economic range for dual conductor lines are about 25 per cent larger than those for single conductor lines. It is noteworthy that the curve of transmission cost versus line voltage for the short and medium distances is relatively flat at the higher voltages. Fig. 1 indicates that bundled-conductor transmission, desirable at higher voltage levels because of radio-influence and corona-loss considerations, may also be attractive at lower voltages from an economic standpoint.

The relative costs of expanding a transmission system by adding more low-voltage transmission circuits or by superimposing a higher voltage depends on the distance involved, the adequacy of the existing system, and probably most important—the amount of the added load to be supplied. Fig. 2. shows that a load increase of about 100 per cent is required to justify superposition of 330 kv on an existing 50-mile 4-circuit 115-kv system. These results are also typical of those obtained for superposition on existing 138- or 161-kv moderate-distance transmission systems—that is, extra-high-voltage may be economical for load increases of about 100 per cent. Where 230 kv is the established voltage, and providing the transmission distance is 100 miles or greater, 330 kv may be economically superimposed for a load increase of about 75 to 100 per cent.

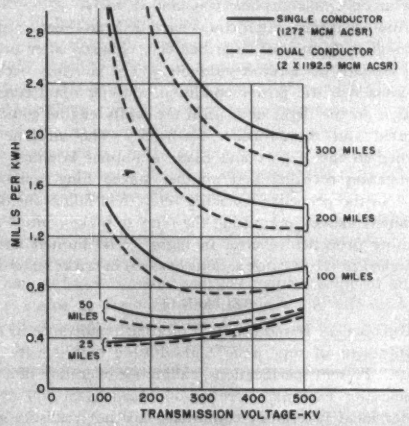


Fig. 1. Electric-energy transmission cost vs voltage

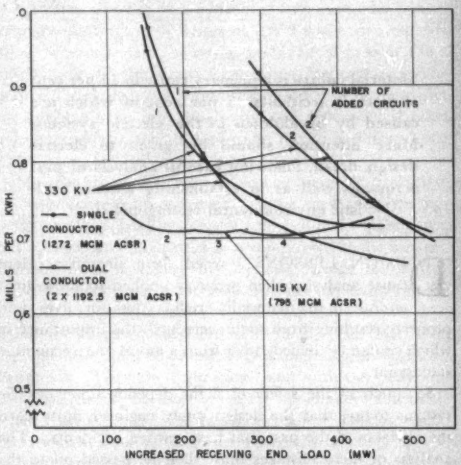


Fig. 2. Cost of expanding a 50-mile 115-kv transmission system

The results of this study indicate a trend toward higher transmission voltage caused by the increasing costs of transmission lines, primarily because of the difficulty in obtaining economic rights-of-way. This trend is also influenced by the fact that recent technological advances in equipment design and the widespread use of forced-oil air-cooled solidly grounded neutral transformer banks have resulted in equipment costs which do not rise as rapidly with transmission voltage. Inasmuch as it is expected that this trend will continue, transmission systems should be expanded at the highest voltage in the economic range in order to realize the greater flexibility and economy that these voltages will afford in the future.

Digest of paper 56-215, "An Economic Study of High-Voltage Transmission," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

A. J. Wood and J. M. Henderson are with the General Electric Company, Schenectady, N. Y.

Flight Safety Aspects of Electrical Design

W. F. FUNK

Material failure is a primary cause in 25 per cent of aircraft accidents—3 per cent of which are caused by breakdown in the electric systems. More attention should be given to electric design detail, following careful analysis of past errors, as well as to establishing a more realistic environmental testing policy.

DESIGN LESSONS learned from aircraft accident cause analysis, when properly applied to subsequent aircraft, can materially reduce loss in lives and property resulting from such accidents—the importance of which cannot be denied either from a moral or an economic standpoint.

So much of the safety of flight depends upon electric systems today, that the design safety engineer must learn the mistakes of the past that have caused accidents. The analysis of these mistakes must then be passed on to the designers, so that the same errors will not be made in future design.

STATISTICAL SUMMARY

FROM A STUDY of aircraft accident losses, it is found that during a one-day period the U. S. Air Force destroys or substantially damages 4.6 aircraft in major accidents. This amounts to an average loss of more than $1 million per day. Statistics indicate that material failure is a primary cause factor in 25 per cent of the total accidents; of these, 3 per cent is directly caused by failure of a component or a breakdown of an aircraft electric system.

Of the total accidents in the Air Force, 48 per cent is attributed to crew error as a primary cause factor. Of this 48 per cent, an unknown quantity presents itself in the form of a question—was the accident caused by crew error, or was it caused by design error?

DETAIL DESIGN

DESIGN LESSONS learned from accident statistics indicate that present-day aircraft electric systems are basically well designed. However, the matter of detail mechanical design in electrically operated components must be improved to reduce the accident potential. All too often, detail mechanical design is left to inexperienced design people in the electrical design groups; then in the rush to meet a schedule, these detail design items, no matter how important, are passed hurriedly through the checkers, then through the group and project engineers, with a very serious error in the design. Perhaps, the electrical engineer is often too engrossed in the habits of the electrons to take note of the mechanical devices that control these electrons.

The examples that follow indicate, rather forcefully, certain detail design discrepancies that have occurred on a large bomber airplane.

Two incidents that could have been disastrous involved the simple detail of staked hinge pins. A fuel control valve was so designed that during normal operation the valve would be operated by an electric motor but, if necessary, the electric motor could be swung aside, exposing a key that would operate the valve manually in the event of electrical failure. During a climb to extreme altitude with minimum fuel on board, it became necessary to switch to the last remaining full tank that was to carry the airplane over the target and home to its base. When that tank was selected by the flight engineer, nothing happened, and an immediate loss of fuel flow resulted. Needless to say, the airplane descended rather rapidly while the engineer attempted to utilize the small amount of fuel remaining in the other tanks. As soon as an unpressurized altitude was reached, the second engineer crawled into the wing of the aircraft and operated the tank valve manually. It was found that the hinge pin, which had been staked, had fallen from the valve and that the electric-motor portion had fallen free from the valve assembly. Fortunately, this airplane was landed safely.

Another instance that could have been fatal occurred on take-off with another large bomber. Shortly after breaking ground, the aircraft suddenly yawed violently because of an assymetric power condition, causing some consternation on the flight deck until the faulty engine could be located and the propeller feathered. The airplane returned to the airport and made a normal landing. Investigation revealed that another staked hinge pin, this time in the propeller reversing relay, had fallen out of its retainer, thereby permitting the relay to make contact and causing propeller reversal in flight. The limited fatigue of staked pins can cause serious hazards in critical circuits.

RELIABILITY

RELIABILITY is another item of great importance in current design of supersonic high-altitude high-density aircraft. Present specifications, calling for operation of a test article (for example, a relay) for perhaps 50,000 cycles under ideal laboratory conditions, are not realistic, so a new item should be flight tested long before it is ready for production. Also, is 50,000 cycles of operation enough to

Full text of a paper DP 56-467 presented before a session of the AIEE Committee on Air Transportation, AIEE South West District Meeting, Dallas, Tex., April 2-4, 1956.

W. F. Funk is with Convair, Fort Worth, Tex.

satisfy the rigorous requirements of today's airplane? Perhaps for certain applications, a million cycles of an electric apparatus should be called for under varying conditions. Put this relay in the snow, rain, bitter cold, and broiling sun during its operation, instead of letting it sit in a room at 70 F, and then give it the high- and low-temperature tests required. In other words, this is a plan for more realistic specifications, based on flight tests, rigorous outdoor ground tests, and true environmental conditions. Engineering-test efforts should be applied to more realistic specifications and to more rigorous environmental testing of electric and electronic components to achieve a higher reliability factor. In addition to temperature, moisture, fatigue, and altitude environments, the maintenance and servicing environment should be included in this more realistic testing. Consider the maintenance and supply human factor, whereby a piece of electric equipment is pushed around in supply rooms, and it is bumped or stepped upon by mechanics after installation in the airplane. The item must be tested for ruggedness under actual working conditions.

Thousands of unsatisfactory reports on electric components are contained in the files of the Air Force Inspector General's Weapons Analysis Division. However, statistics are not presented herein, because this type of information is made available to contractors. These huge files are caused to a great extent by lack of reliability created by unrealistic specifications. From the standpoint of the government contractor, it must be realized that our national economy cannot tolerate such waste that is based upon unrealistic proof of the product.

HUMAN FACTORS

PHYSICAL CHARACTERISTICS and environmental limitations of man have not changed very much since the Stone Age, but in a period of only 50 years, man has propelled himself, as well as his limitations, into the dimension of flight. He now has aircraft that will take him higher, farther, and faster but, basically, he is still the same man. He cannot breathe rarified air any better than his cave man ancestors, nor can he operate a control with any more strength than the cave man required to swing an axe (probably not as much). He cannot see any farther or hear any more clearly, so here again are definite limitations that must be considered in design.

In past years, it was the custom to design an item, such as an airplane, stove, drill press, or automobile, and sell it with the premise that the operator could tailor himself to the manner in which it was designed. However, this thinking is undergoing considerable change with the advent of common-sense human engineering. Human engineers are now at work in many industries endeavoring to tailor the machine to the man. In the design of our modern aircraft it is extremely important to tailor this high-altitude high-speed ultracomplex machine to the man or the air crew that is to operate it.

An air crew is surrounded with a multitude of gadgets, switches, gauges, instruments, and other equipment, and is expected to fly and fight successfully with a military aircraft or to carry airline passengers safely to their destination with a transport; hence, very careful consideration must be given to this matter of tailoring the machine to the man. To illustrate what is meant by the design-error versus human-error factor, it is quite probable that the following accident analysis, involving the loss of several jet fighter aircraft, reveals the primary cause to have been a design oversight.

A fighter airplane is approaching its base under instrument conditions at 450 knots at 2,000 feet above the terrain. The pilot calls the tower, and is asked to switch to a different tower frequency for landing instructions. The pilot acknowledges the transmission and shortly thereafter the airplane dives into the ground—at 450 knots, it takes only 4 seconds for the airplane to hit the ground from 2,000 feet.

An analysis of this type of accident reveals a possible behavior pattern upon the part of the crew member that is extremely unhealthy from a safety-of-flight standpoint, but is based on the location of a component in the cockpit. For the pilot to make the required change to another radio frequency, he must first take his left hand off the throttle, and place it upon the stick—normally he would be flying the airplane with his right hand. He must then turn his head and, of course, stop monitoring his flight instruments. With the right hand, and with the body and the head turned, he must reach for the channel and mode selector on the right wall of the airplane. This operation takes several seconds—while in 4 seconds, the airplane will strike the ground.

On a different type of airplane another item of detailed design presented itself in a very serious manner involving the loss of fingers. A portable cabin electric heater was included to provide both heat and ventilation within the cabin. The fan rotated at a very high speed, but did not incorporate an adequate guard over the fan blades. This resulted in several occurrences of crew members becoming dismembered when they would lift the heater at the air outlet rather than at the lifting handle. This problem was eliminated by the use of a coarse screen such that a man could not insert his hand through the opening of the fan housing. Here again, is the blame on the man, or on an oversight in design?

STANDARDIZATION

A VERY IMPORTANT CONSIDERATION in the design of the machine for the operator is one of standardization. To date, some excellent progress has been made in the standardization of control knobs and levers in that miniature wheels for landing gear controls, miniature airfoil surfaces for flap controls, and many other items that permit the pilot to differentiate his controls by feel are in use today.

A lack of standardization of controls has caused many accidents. One example of nonstandardization occurred on a multiengine aircraft, in which to operate the mixture controls on one type, the control was pushed away from the operator to shut off the engine. On a later type, the control was pulled toward the operator to shut off the engine. During one flight in one of the later types, it was necessary, because of the failure of one engine, to advance the mixture for additional power on the remaining engines.

The engineer, highly experienced on the earlier type, acted instantaneously to provide the necessary power by pulling back on the mixture controls, thereby shutting off the remaining three engines. The result of this action in an emergency situation resulted in the loss of several lives—nonstandardization had claimed some more victims.

An automotive example may be used to illustrate the possible effect of human reaction caused by formation of habit patterns. If a person had purchased an automobile equipped with a standard transmission, and the manufacturer had reversed the location of the clutch and the brake from their normal location, but had warned the driver about the change, the driver would be capable of driving the vehicle successfully during normal conditions. However, when an emergency condition suddenly presented itself, he would act instantaneously with the right foot for the brake (since on his earlier model, the right foot operated the brake). In this case, however, the right foot would be placed on the clutch because of the habit pattern, and lack of standardization would have added a highway statistic.

It is not a simple matter to achieve standardization. When a group of men assemble to discuss standardization, none of them will agree all of the time on the location of every item on a control panel, or even on the location of the control panel itself. However, for safety of flight items, electric switch panels and warning panels should be standardized from type to type and from model to model, so that the operators will not be jeopardized by nonstandard panels. A designer of a piece of equipment certainly does not intend to be a part of, or the cause of, an accident.

UNDERGRADUATE ENGINEERING TRAINING

To CREATE SAFETY CONSCIOUSNESS early in the career of the design engineer, engineering schools should include in their curriculum certain design teaching based on limitations of the human operator and upon accident analysis. Such teaching could possibly be included in the machine-design classes.

DESIGN SAFETY PARAMETERS

SAFETY IN AN INDIVIDUAL DESIGN can be accomplished to a large extent by the designer asking himself the following questions:

1. Is there a weak link in the design? How can it be eliminated economically?
2. Is the design as simple as possible, commensurate with the task it is to perform?
3. What are the possible consequences of failure of any component in the design? Is it fail safe?
4. If a component can be installed in reverse, will it cause disaster?
5. What are the possible consequences of an error in operation? Can they be eliminated by additional study?
6. Has a working model of cardboard, wood, and modeling clay been made to enable better visualization of the foregoing points?

CONCLUSIONS

To EMPHASIZE the basic factors discussed, therefore, it can be concluded that good design can save lives by:

1. More attention being given to detail mechanical design of electric components and controls.
2. A more realistic environmental testing policy being established for all aircraft electric and electronic equipment, and all applicable specifications should be reviewed from an operational suitability standpoint.
3. The maintenance environment which must be considered in the design of all-electric components and systems.
4. Thorough education, in that the designers must be made aware of the limitations of the human operator.
5. The machine being tailored to the man.

Transients Studied at Reactor Testing Station

View, at left, was taken looking down into the water-filled tank of the SPERT-I (Special Power Excursion Reactor Tests) reactor, self-lighted by blue radiation glow. Above the tank are control mechanisms and their supports. Projected down into the tank are two of four T-shaped rods carrying cadmium control "blades." In the center of the tank is the central control rod that is used to initiate the sudden rises in power this reactor was built to study. The network of squares helps support the fuel.

This photograph was made during a transient in which the power rose from an initial 2 watts to 510 megawatts (mw) in 0.75 second. Period (rate at which power increases) was 13 milliseconds. Energy release was 16 mw-seconds.

The SPERT I Reactor, used for studies of reactor transients, was designed and is operated by Phillips Petroleum Company, Idaho Falls, Idaho, under contract to the Atomic Energy Commission.

Contactor Servo Uses Describing-Function Theory

S. K. CHAO
ASSOCIATE MEMBER AIEE

CONTACTOR SERVOMECHANISMS, studied for a number of years, are widely used because the contactor contained in the system provides a large gain.

Applicability of this method to practical design problems has been demonstrated so far largely through the help of computers where a "designed" servo system is simulated and its performance computed. A contactor servo, based on the theory of describing-function method, is detailed.

The contactor selected is a moving-coil type of polarized sensitive relay. Its contact spacings at both sides can be adjusted at will to give the desired value of dead zone. The relay is used not only as the nonlinear contactor, but also as an error-sensing element. Coulomb friction, contact arcing, and other nonlinearities usually inherent in a contactor servo are reduced to a practical minimum. In order to compare the practical results and those predicted through describing-function theory, the contactor servo is designed to be oscillatory with adjustable amplitude of oscillation.

Whenever possible, expressions or values for the servo (Fig. 1) are determined experimentally. The open-loop transfer function is

$$\frac{e_o}{e_s} = K_{RC} G_{RC}(s)(1/\Delta_C) N(\alpha) \frac{W}{s(\tau_m s+1)} K_B$$

where

K_{RC} = relay-circuit static gain = 0.011 radians per volt
$G_{RC}(s)$ = nondimensionalized relay-circuit transfer function = $\dfrac{1}{(s/\omega_n)^2+2\zeta(s/\omega_n)+1}$
ω_n = resonant frequency of relay circuit = 42.6 radians per second (varies slightly for various voltages carried on contacts)
ζ = damping ratio of relay circuit = 0.50, 0.42, or 0.37, depending on the voltage carried on contacts
Δ_C = contactor dead zone = 0.025 radians
$N(\alpha)$ = contactor describing function, nondimensionalized
α = nondimensional amplitude of system sustained oscillation
W = motor runaway velocity = 57.0, 82.0, or 88.5 radians per second, depending on the magnitude of motor control field voltage
$1/s(\tau_m s+1)$ = transfer function of 2-phase control motor
K_B = feedback constant; its value is adjustable through the d-c voltage applied to the feedback bridge; V = 0.191 volt per radian

Dead zone Δ_C of the contactor depends primarily on the separation of contacts. It is also affected by electrostatic attraction and contact arcing. Hysteresis Δ_h exists because relay pull-in current is always larger than drop-out current. In the sensitive relay used, it is affected mainly by attraction, arcing, and vibration. For an oscillatory system, it is necessary to have small Δ_C, large Δ_h, and consequently a relatively large value of Δ_h/Δ_C. In the system designed,

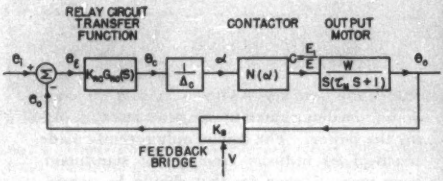


Fig. 1. Servo system

Δ_h is 0.004 radian, making the ratio Δ_h/Δ_C equal to 0.16.

The variation of ζ and ω_n for various contact voltages is caused by electrostatic attraction and contact arcing. When higher voltage is applied across the contacts, the attracting force between contacts is increased. As the contacts are approaching each other, this force will accelerate and finally pull them closed. Thus, for a given contact opening, the effective result of a higher voltage across the contacts is a decrease of input voltage to relay coil for the contacts to close, and is equal to an increase of contactor gain.

Two variable parameters, the runaway velocity W and the feedback constant K_B, were used to adjust the system gain such that different stability conditions could be studied. Five stability conditions were established through the adjustment of these parameters.

For each condition, the linear portion of the system transfer function was calculated and plotted on the gain–phase plane. When the curve for the composite linear transfer function intersects with the curve for nonlinear portion, the amplitude and frequency of oscillation were noted and compared with those recorded on an oscillographic recorder.

Since describing-function method neglects coulomb friction, it is applicable only to contactor servo where coulomb friction is small compared with motor torque. Larger output motor can be used to belittle the influence of friction effect. For conditions where larger motor is not advantageous, it is suggested that the contactor describing function be modified to include the effect of coulomb friction.

The discrepancy between theoretical prediction and experimental results in amplitude and frequency of oscillation ranges from −6.75 to +28.1 per cent. This is within engineering accuracy, considering the fact that most parameter values are experimentally determined.

The voltage carried by the contacts of the relay in a contactor servo is of vital importance to the performance of the system. It influences directly the value of the contactor dead zone, the contactor hysteresis, the contactor-circuit transfer function, and indirectly, if the output motor is immediately following the contactor, the motor time constant and the motor runaway velocity. This voltage should be carefully considered in designing contactor servo.

Digest of paper 56-456, "Design of a Contactor Servo Using Describing-Function Theory," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE-ASME Nonlinear Controls Conference, Princeton, N. J., March 26–28, 1956. Scheduled for publication in the AIEE *Applications and Industry*, 1956.

S. K. Chao is with Atomic Instrument Company, Cambridge, Mass.

Adjustable-Voltage Hoist Drives for Cranes

S. RIFKIN
MEMBER AIEE

The adjustable-voltage drives for hoist motion of cranes use d-c motors with speed and direction of rotation determined by the generators supplying the power. The drives, only recently made practical for industry from a cost standpoint, have many advantages that should be considered by designers.

ADJUSTABLE-VOLTAGE DRIVES are not new—in fact, the basic circuit was patented in 1891. An adjustable-voltage drive, frequently referred to as a Ward-Leonard drive, is one that utilizes a d-c motor on the machinery, with the speed and direction of rotation determined by the voltage and polarity of a generator supplying power to that motor.

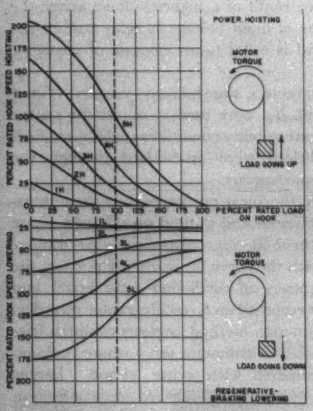


Fig. 1. Typical speed–load characteristics for the maxspeed adjustable-voltage hoist system.

This principle was used on a coal unloading tower as long ago as 1923, and may have been used on other materials handling applications before that. With the advent of the General Electric Company's "maxspeed" system[1] in 1940, adjustable-voltage hoists began to be utilized on more cranes. This system, providing empty hook speeds on the order of 200- or 250-per-cent rated full-load hoisting speed, is tailor-made for each application. The general shape of the speed–load curves provided are shown in Fig. 1. Among the many interesting installations utilizing the maxspeed system are the Fontana Dam (Fontana, N. C.) construction gantries (Fig. 2) and Hunters Point Naval Shipyard (San Francisco Bay area) cranes (Fig. 3), considered to be the largest overhead traveling cranes in the world. The Hunters Point cranes are the ones that set a 450-ton load down on a raw egg without cracking the shell, in order to demonstrate accuracy. Because of the extremely satisfactory performance at Fontana Dam, the maxspeed system was specified for the five gantries now being used in the construction of Bahkra Dam, India. In addition, maxspeed has been used for 600 cargo winches on the Mariner Class ships.

SPEED VARIATORS

BECAUSE of the relatively high cost of the special motor-generator set with the cross-flux exciter, the maxspeed system was not considered to be economically justified on general purpose cranes. However, the tremendous increase in the use of adjustable-voltage drives for machine tools, conveyors, textile machines, the lumber, steel, and automotive industry has led to quantity production of packaged motor-generator sets and control panels. In accordance with the basic principles of the free-enterprise system, quantity production has led to design improvements and price reductions; consequently, the General Electric package, called the speed variator, has been used on several cranes, starting in 1951, for lumber mills, machine shops, metal-working plants, factories, and large power plants. Fig. 4 shows the simplicity of mounting the main hoist and auxiliary hoist speed variators on the bridge walkway of a machine-shop crane.

SHUNT-WOUND HOIST MOTORS

ASSUMING 3-phase a-c incoming power, the elementary diagram for a speed variator crane hoist system with a shunt-wound motor is shown in Fig. 5. The speed and direction of rotation of the d-c motor is determined by having the master switch contacts control the strength and direction of current flow in the generator shunt field. Naturally, the interrupting rating of the master switch contacts must be adequate for the highly inductive generator field current. For some ratings, it may be necessary to provide Alinico blowouts on some of the master switch contacts; for high horsepower ratings, small contactors are used to handle the generator field current. On floor operated cranes of all ratings, small contactors are used instead of attempting to handle the generator field current in the pushbutton station.

Full text of a paper presented at the AIEE Materials Handling Conference, Cleveland, Ohio, March 28–29, 1955, and recommended for publication by the AIEE General Industry Application Committee.

S. Rifkin is with the General Electric Company, Schenectady, N. Y.

Fig. 2. Cantilever gantries with the maxspeed hoist system for placing concrete at Fontana Dam.

Fig. 3. Hunters Point Naval Shipyard cranes with maxspeed hoists, considered the largest traveling cranes in the world.

In order to prevent shock to cables and gears and to provide good commutation in the motor and generator, it is essential to keep the generator voltage from increasing or decreasing more rapidly than the speed of the load can change. This problem cannot be passed over lightly. It might be solved by building long time constants into the generator and d-c motor, but the advantage of large quantity production would be lost if special units were required, and it would be difficult to adjust "built-in" time constants when the crane is installed. Consequently, the speed variator includes a damping motor in the generator field circuit to provide the same method of obtaining smooth acceleration as has been used for many years on adjustable-voltage elevators.

On almost all adjustable-voltage hoists, d-c brakes have been used because there is a supply of constant potential direct current available for the motor and generator fields. The arrangement is "fail-safe" because loss of the d-c supply will result in setting the brake and reducing the generator voltage. It should be noted that only seven collectors are required, including two for the control-type overhoist limit switch. Even the simplest a-c wound-rotor hoist with a limit switch requires eight collectors, and the more elaborate systems may require as many as 12 collectors.

The speed–load characteristics obtainable with a shunt motor on an adjustable-voltage hoist are shown in Fig. 6. The relatively flat lowering curves are excellent on any installation where accurate positioning is required for a wide range of loads. Enthusiastic comments have been received from operators on machine shop and loading area cranes.

The motor speed on the first lowering point can be made either slower or faster and the stalled torque on the first hoisting point can be adjusted to a higher value, if desired, by simply moving a control wire on a small resistor in the speed variator. These adjustments are certainly much easier to make than moving large cables or changing power resistors. Notice also that the maximum empty hook hoisting and lowering speed is approximately 115 per cent, which is a slight bonus over the synchronous speed obtained at no-load for any type of wound-rotor system.

COMPOUND-WOUND HOIST MOTORS

By using a compound-wound hoist motor with the same basic speed variator equipment just described, it is possible to obtain fast empty hook speed, as shown by the characteristics in Fig. 7. The ratio between the no-load and full-load speeds on the fifth hoisting point is dependent upon the no-load generator voltage and the proportioning between series- and shunt-field strength in the compound-wound motor. The ratio of no-load to full-load hoisting speed could easily be increased by increasing the series field and decreasing the shunt field of the compound-wound motor; however, there would then be a possibility of unstable operation in the lowering direction.

When lowering a load, the d-c hoist motor will tend to pump current back into the generator. Since the polarity of the generator when lowering is the opposite of the polarity when hoisting, the pumpback lowering current will actually flow through the motor series field in the same direction as the hoisting current. In other words, a heavy load will result in a stronger total motor field strength and a slower speed than an empty hook. However, the flow of motor series field current during acceleration in the lowering direction would oppose the shunt field and could result in overspeeding the motor; therefore, some provision must be made to by-pass the series field during this acceleration interval.

Fig. 4. Main and auxiliary hoist speed variator power units mounted on the bridge walkway of a machine-shop crane.

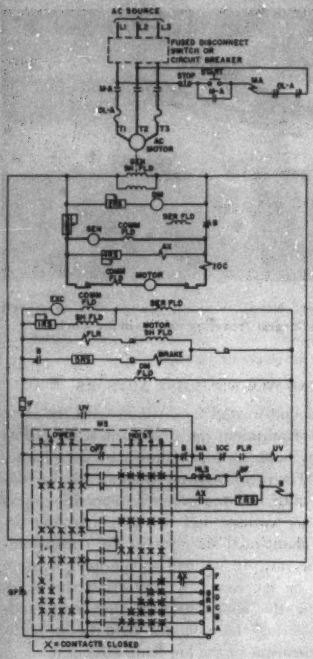


Fig. 5. Elementary diagram of speed variator hoist drive with a shunt motor.

AX—Acceleration relay, B—Brake contactor, DM—Damping motor, FLR—Field loss relay, GF—Generator field contactor, HLS—Hoist limit switch, IOL—Overload relay, MA—Motor starter, MS—Master switch, FU—Fuse, RS—Resistor, UV—Undervoltage relay.

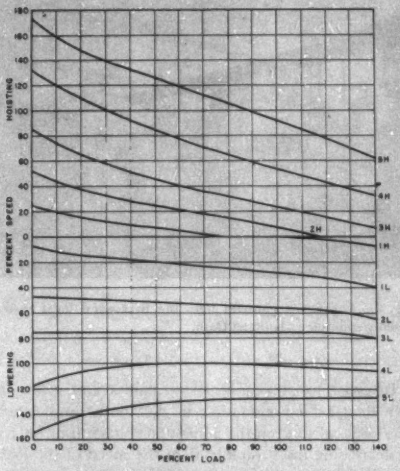


Fig. 7. Test speed–load curves of V-30Y speed variator with 40-hp compound-wound motor; 100-per-cent load corresponds to rated motor current hoisting.

Fig. 8 shows how the power connections of Fig. 5 are modified when a compound-wound motor is used. The combination of rectifier and resistor mounted near the motor results in minimizing the reverse current flow through the motor series field. Fig. 9 shows an alternate method of making connections as published by another electrical manufacturer to meet similar operating requirements.

CONCLUSIONS

THE USE of adjustable voltage on the hoist motion of cranes is not new, but it has only been a few years since a system has been made available that is competitive in price with other a-c systems that provide reasonable speed control in the lowering direction. The advantages of the speed variator drive may be summarized as follows:

1. Acceleration and deceleration are smooth. The circuit makes it impossible to apply torque peaks as suddenly as when a wound-rotor resistance is short circuited. Fig. 10 shows the d-c motor armature current, voltage, and speed traces obtained on an oscillograph when stopping rated load from the fastest lowering speed. Although the change in armature current is quite smooth, the stopping time is still a reasonable value. If desired, a shorter stopping time can be obtained by adjusting the drop out of relay *AX*, so that the brake will set at a faster motor speed.

2. There are fewer contact conductors to the movable trolley. Only seven conductors are required, including two for the hoist limit switch; compared to eight conductors for the simplest a-c system, and as many as 12 for the more elaborate a-c systems.

3. The fast empty hook speed provided by the compound-wound motor can be extremely important on a crane that is used frequently. Six lumber-mill cranes equipped with this system have been in use an average of 16 hours a day, 6 days a week, since June 1951. On those installations, it is always necessary to raise the empty grapples after a load has been deposited in order to clear the piles of lumber when returning for the next load. By gearing for a slightly slower full-load speed than originally contemplated, it was possible to use a 40-hp motor and to meet the required operating cycle in a shorter time than would be possible with a 50-hp wound-rotor motor.

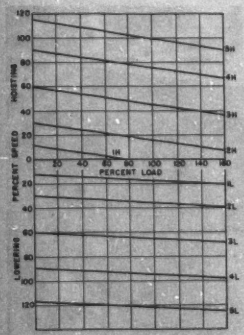


Fig. 6. Speed–load curves of speed variator using shunt-wound motor; 100 per-cent load corresponds to rated motor current hoisting.

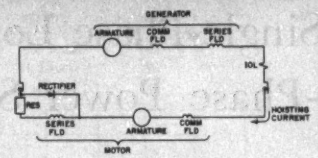


Fig. 8. Power circuit of Fig. 5, when compound-wound motor is used.

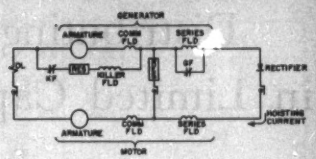


Fig. 9. Power circuit published by another electrical manufacturer.

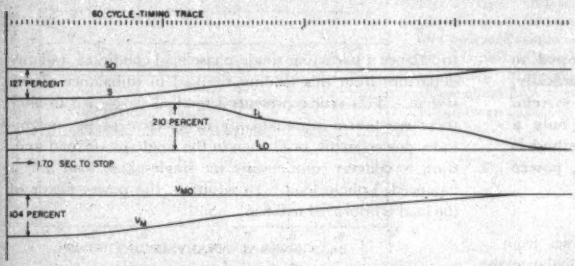


Fig. 10. Tracing of oscillogram with master switch moved from fifth lowering point to OFF position with 100-per-cent rated load using a compound-wound motor. *S—Speed trace, S_O—Speed base line, I_L—Loop current trace, I_{LO}—Loop current base line, V_M—Motor armature voltage trace, V_{MO}—Motor armature voltage base line; 100 per-cent current flows when hoisting rated load; 100 per-cent voltage is rated motor voltage.*

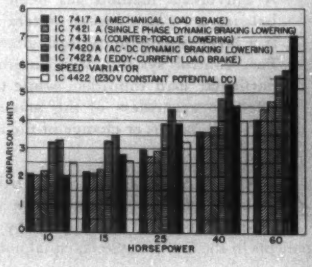


Fig. 11. Price comparison of hoist electric equipment.

4. Relatively slow landing speed for all loads is provided on the first lowering point. This is especially true of the shunt-motor system, which provides approximately the same speed for rated load as for a light load—a feature that is extremely popular with the crane operators in a machine shop, where a large variety of loads must be accurately positioned in machine tools.

5. The power loss in resistors is negligible, and there is no power loss in mechanical or electric load brakes.

6. There is less control maintenance, since there are so few control devices, and no contactors are required to interrupt the power circuit, except when the motor-generator set is shut down.

7. Brake-lining wear and brake-wheel heating are reduced to minimum values because the speed of the load is decreased electrically before the brake sets.

8. There is less wiring at the time of installation. All connections between the control panel and the motor-generator set are completed in the factory. The large number of power cables required between the control panel and the secondary resistor for a wound-rotor motor are not necessary with an adjustable-voltage drive.

9. Adjustment of the speed–load characteristics can be easily made by moving control wires on small resistors in the speed variator instead of moving power cables on large resistors, as would be necessary with a wound-rotor motor.

10. A d-c brake may be used on any motion, if desired, since the speed variator includes a 230-volt d-c constant-potential exciter.

11. Up through 40 hp, the cost of the speed variator equipment is competitive with other magnetic control systems that provide slow landing speed for rated load without a mechanical load brake. Fig. 11 shows a cost comparison of various systems, based upon the following equipment: (a) a 1,150-rpm crane-duty open solid-frame motor (shunt wound for the speed variator); (b) a magnetic control panel in a National Electrical Manufacturers Association (NEMA) Type I general-purpose enclosure (speed variator does not require a separate control panel); (c) one a-c brake and wheel for use on a wound-rotor motor or one d-c brake and wheel for use on a d-c motor—rated brake torque is equal to or greater than rated motor torque; (d) class *162* nonbreakable-type resistors (speed variator with a shunt motor does not require separately mounted resistors); (e) a heavy duty 5-speed master switch; and (f) an eddy-current load brake purchased separately by the crane manufacturer for use with the *IC7422A* control panel.

Of course, open control panels and class *152* cast grid resistors would reduce the cost of the various wound-rotor systems, but that equipment would not be comparable to the speed variator. It should also be noted that this comparison does not include the cost of a mechanical load brake for the *IC7417A* control, nor has any attempt been made to show the reduced installation cost of the speed variator, because of fewer collectors and the elimination of several resistor cables.

REFERENCE

1. A New Electric Hoist Drive for Cranes, M. A. Whiting. AIEE *Transactions*, vol. 63, February 1944, pp. 59–64.

Distributing Large Single-Phase Loads in Limited Capacity 3-Phase Power Systems

G. F. AROYAN K. G. LAKEY

A conversion method has been developed to balance a 3-phase power system automatically, if a large single-phase load alters the system. Past control systems were useful for only a particular load condition, while this method is effective regardless of the magnitude, power factor, or change in the load.

A LARGE SINGLE-PHASE LOAD drawn from a limited capacity 3-phase system will unbalance the 3-phase system. If analyzed by symmetrical components in the 3-phase system, equal and opposite positive and negative sequence currents are realized. This unbalance leads to excessive heating in the stator of the alternator, thus reducing its over-all capacity substantially. If uncorrected, the unbalance may also cause local hot spots in ordinary induction motors.

The methods of balancing the 3-phase load employ various types of large rotating machinery. Static methods using various transformer arrangements, unsymmetrical taps, etc., have been used, but none of these methods eliminate the negative sequence current, which is the cause of the unbalance.

A tapped reactor and capacitor have been used on electric welding machines in Great Britain,[1] as well as to balance a large single-phase load to 3-phase aircraft inverters.[2] In these two applications, however, the units were designed to balance a particular single-phase load condition, and any departure from this loading resulted in unbalance of the system. This article presents a method developed to alter these reactances automatically irrespective of the magnitude, power factor, or change in the single-phase load and, thus, to convert continuously the single-phase load into a balanced 3-phase load. In addition, the power factor of the load is improved to 0.866.

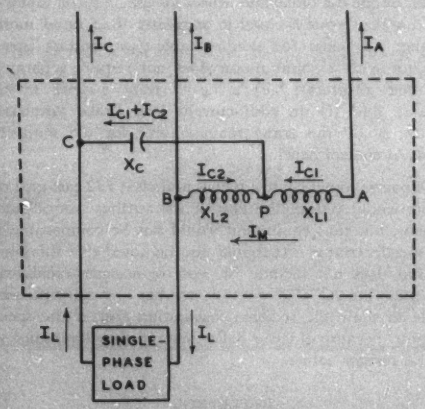


Fig. 1. Basic static converter.

GENERAL ANALYSIS

A SCHEMATIC DIAGRAM of the basic power elements of the converter unit is shown in Fig. 1. The power elements consist of a capacitor and a tapped reactor, connected across the 3-phase system. The three phases are *A*, *B*, and *C*, and the single-phase load is connected across line *BC*; the midpoint connection between capacitor and inductance

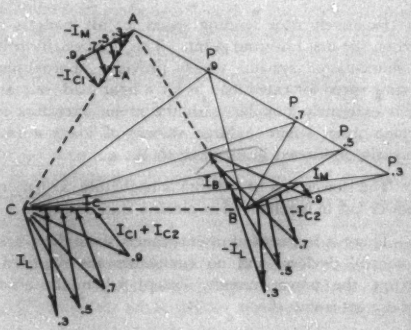


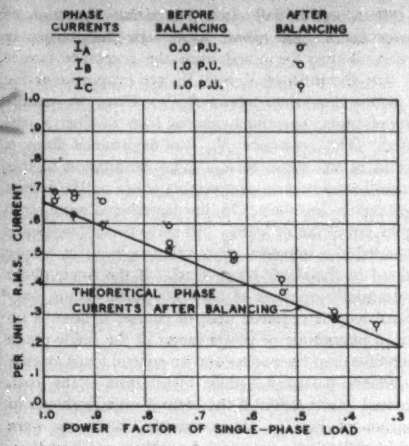
Fig. 2. Vector diagram of graphical analysis.

is *P*. The currents I_A, I_B, I_C are the reflected 3-phase currents into the power source. The load current is I_L; current through the capacitor is $I_{C1}+I_{C2}$. I_{C1} and I_{C2} are the division of this capacitive current through the inductive reactance. The current I_M is the current through the reactor induced by the line voltage V_{AB}. If X_C is the magni-

Full text of a paper 56-625, recommended by the AIEE Committee on Industrial Power Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Scheduled for publication in AIEE *Applications and Industry*, 1956.

G. F. Aroyan is with the University of California, Berkeley, Calif.; K. G. Lakey is with the U. S. Navy, San Francisco, Calif.

The work was performed by the authors in partial fulfillment of the requirements for the degree of Naval Engineer at the Massachusetts Institute of Technology, Cambridge Mass., and was supported by the U. S. Navy, Bureau of Ships. The authors wish to thank D. P. Campbell, Prof. of Electrical Engineering, for his encouragement and guidance as thesis adviser.



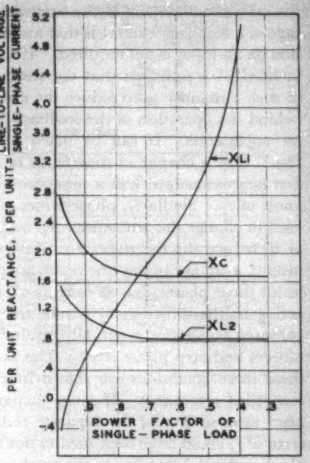


Fig. 3 (left). Observed phase currents for manually operated reactances. Fig. 4 (right). Required reactances to convert single-phase load to balanced three phases.

tude of capacitive reactance, X_{L1} is the value of the inductive reactance between P and B, and X_{L2} is the inductive reactance between P and B, the following relations hold:

$$I_A = -I_M - I_{C1} \tag{1}$$

$$I_B = I_M - I_L - I_{C2} \tag{2}$$

$$I_C = I_L + I_{C1} + I_{C2} \tag{3}$$

and

$$jX_{L1} = \frac{V_{AP}}{I_M + I_{C1}} \tag{4}$$

$$X_{L2} = \frac{V_{PB}}{I_M - I_{C2}} \tag{5}$$

$$-jX_C = \frac{V_{PC}}{I_{C1}} + I_{C2} \tag{6}$$

Fig. 2 is a vector diagram of the graphical analysis carried out for various values of load power factor as the variable. The figure indicates the change of currents and voltages required for the single-phase load to produce balanced 3-phase currents. The reactances were normalized with respect to the load current and line voltage. For any particular power factor, the reactances, phase currents, etc., vary directly with the magnitude of the load current. Under balanced conditions, the 3-phase currents are equal and are in phase with their respective line-to-line voltages.

The following condition holds relating the balanced 3-phase power to the single-phase load, assuming perfect conversion, no reactance losses, leakage, distortion, etc., thus:

$$3E_\phi I_\phi \cos 30° = E_L I_L \cos\theta \tag{7}$$

$$I_\phi = 2/3 I_L \cos\theta \tag{8}$$

where E_ϕ is the phase voltage, I_ϕ is balanced 3 phase current, I_L is the single-phase load, E_L is the line voltage, and $\cos\theta$ is the power factor of single-phase load. The latter relationship is plotted in Fig. 3 as the "theoretical" value of the phase currents.

Fig. 3 is a plot of the phase currents obtained by using particular reactances for particular loads and shows correspondence between actual observations and the graphical analysis. Fig. 4 is a plot of the required per-unit reactance to balance the single-phase load obtained from the graphical analysis.

CONTROL SYSTEM

A FEEDBACK CONTROL SYSTEM was used to permit self adjustment of the reactances. The change in reactances, as noted in Fig. 4, is linear with respect to load current magnitude, but nonlinear with respect to the power factor of the load. From a study of the vector diagram (Fig. 2), a convenient measure of balanced conditions was observed to be the point at which the 3-phase currents are in phase with the line voltages. This phase measurement was used as

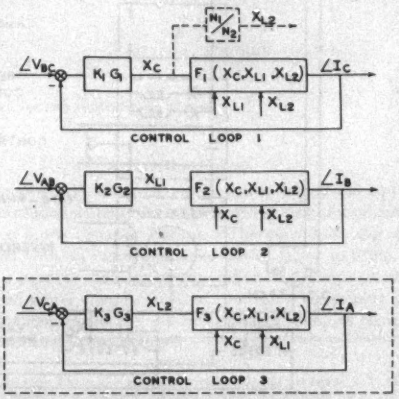


Fig. 5. Control system.

the error measurement of the control system. One advantage of a feedback control is that an exact or precise operation on an input is not required. If stability conditions are satisfied, it is sufficient that the control system merely act in such a manner as to reduce the error. This basically is behind the operation of the feedback loops in this particular application. It can be noted from an inspection of Fig. 2 that a change in magnitude of $I_{C1}+I_{C2}$ (i.e., X_C to a first approximation) had a pronounced effect on the phase angle of I_C. Similarly, phase errors in I_A and I_B could be used to change the reactances X_{L2} and X_{L1} in such a way as to reduce the the respective phase errors. At any one instant, a change in any one reactance gives rise to a change in all three phases, but as long as all three reactances are acting in the direction to reduce the error, a solution of balanced conditions eventually results with balanced magnitudes and zero phase error. The basic control loops for these three conditions are shown in Fig. 5 for separately controlled reactances. If a tap-changing transformer had been used in lieu of the separate inductances, the phase error of I_A could have been used to position the tap, and the phase error of I_B to change the total inductance between A and B.

The system was initially investigated for correction of low power factor single-phase loads. In this particular application, it may be noted from the reactance curves (Fig. 4) that the ratio of X_C and X_{L2} are proportional for power factors less than about 0.75. Thus, to permit economy of units, the third control loop of Fig. 5 was eliminated. The reactance X_{L2} was determined from a direct ratio of the value of X_C. The elimination of this third control loop had no appreciable effect on the results for power factors less than 0.75, but introduced some error into higher power factor loads. All three control loops are recommended if a universal or random power factor may be expected in the single-phase load. If the single-phase load substantially operates at only one power factor, only one control loop is required and, of course, if there is no variation in magnitude or power factor of the single-phase load, then invariant reactances and no control loops may be used to achieve balanced 3-phase distribution of the load.

The actual construction of the control units is shown in the diagram of Fig. 6. The variable reactances were obtained by reflecting a reactance from the secondary of an adjustable autotransformer. The contact of this autotransformer was positioned by a small 2-phase servo motor.

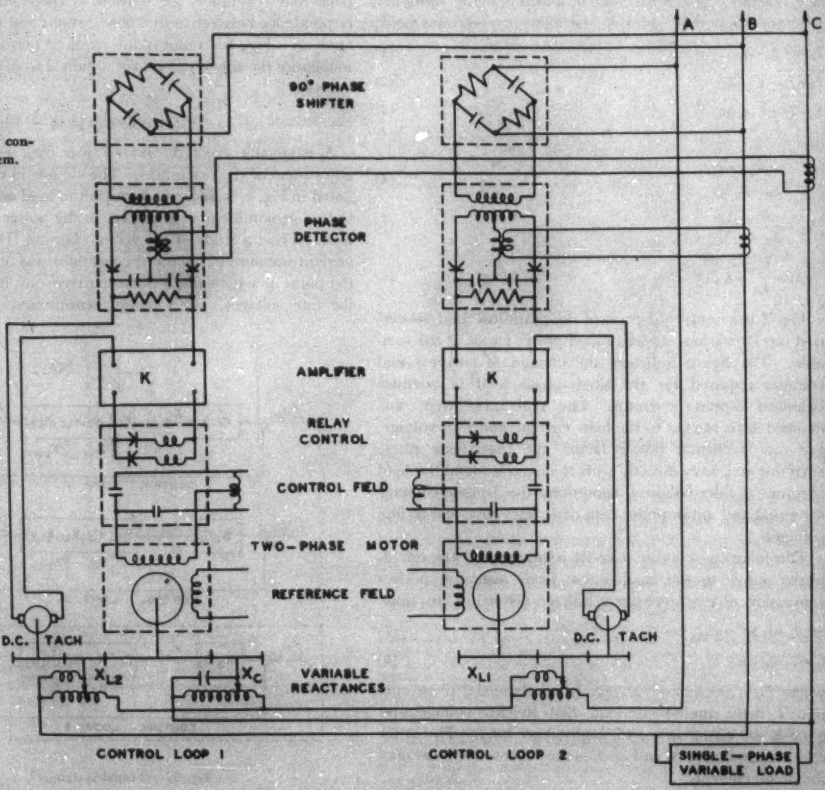


Fig. 6. Two control loop system.

The servo motor received its signal from the phase error of the respective control loop through an amplifier and relay control. A d-c tachometer was added to provide stability of the relay-controlled servo motor. In larger power installations, it is possible to eliminate the amplifier, but at the small power level of the investigation, the amplifier was required to actuate the relay. It is possible to improve the servo-motor response by providing dynamic braking with the relay control, and to eliminate servo-motor excitation under steady-state conditions by proper arrangement of the relays. The object of the investigation, however, was to determine the feasibility of the design and not to consider the extensive techniques and methods for improving the speed of response, error criteria, or other conditions.

RESULTS

THE STEADY-STATE RESULTS are plotted in Fig. 7 for various power factors of the single-phase load. The phase currents for the two control loop system are seen to be in good agreement with the theoretical results for power factors of less than 0.75, as was surmised from the relation of X_C and X_{L2} (Fig. 3). For power factors greater than 0.75, there is still an appreciable improvement over the values of the phase currents before balancing. To determine the effect of three control loops, X_{L2} was disconnected from X_C and was adjusted manually. The sole criterion

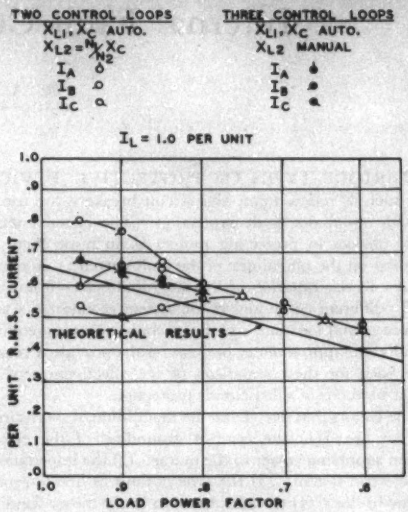


Fig. 7. Steady-state results for two and three control loop system.

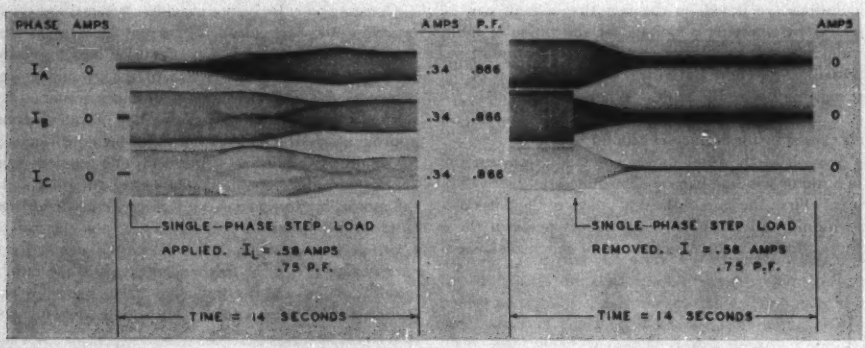


Fig. 8. Transient response of typical step load for two control loop system.

of this manual was the phase error of I_A. The correction was thus applied in the same manner as an actual third control loop. The other two control loops were permitted to adjust their respective reactances X_C and X_{L2} automatically. These results are also plotted on Fig. 7 and indicate good correspondence, with theoretical results over all values of load power factor.

A typical transient response is shown in Fig. 8 for a step application of a single-phase load using the two control loop system. As pointed out earlier, no special effort was made to improve the speed of response, overshoot, etc., since this was not the primary objective of the investigation. Response was satisfactory for most applications.

CONCLUSIONS

THREE-PHASE to single-phase power conversion can be accomplished without the use of large rotating equipment on limited power capacity systems. This conversion is accomplished with an improvement of power factor to 0.866.

It is possible that similar conversion from single-phase to 3-phase power may be effected, but the error sensing and control loop operation will be considerably more complex than the simple one outlined.

REFERENCES

1. Three Phase Distribution of Electric Welding and Furnace Loads, A. L. Morris. *Journal*, Institution of Electrical Engineers, London, England, vol. 93, pt. II, 1946, pp. 341–52.
2. A Unit for Balancing the Voltages of Three-Phase Aircraft Inverters Supplying Large Single-Phase Loads, S. Wimpie. AIEE *Transactions*, vol. 63, 1944, pp. 532–3.

Internal Fault Currents in A-C Motors

R. A. SCHMIDT
ASSOCIATE MEMBER AIEE

VARIOUS TYPES OF PROTECTIVE DEVICES, such as relays, fuses, and circuit breakers, are used to provide a-c-motor fault protection. The effectiveness of these devices in protecting motors is, in most cases, dependent on the magnitude of the fault current. A general answer to this question of the magnitude of fault currents under different conditions of a-c system grounding, system capacity, fault location, and motor connections is presented. Results are approximate, but the results provide a reasonable basis for the comparison of the effectiveness of different methods of short-circuit protection.

The factors that determine the magnitude of short-circuit current are: (1) the type of grounding of the electric system supplying power to the motor; (2) the impedance of the electric system; (3) the type of fault as line-to-ground or line-to-line; (4) the fault location in the motor winding; (5) the magnitude of motor reactance and the division of reactances between the parts of the motor winding; (6) the motor connection, i.e., wye or delta; and (7) the number of circuits in the motor winding.

Calculations are based on the fact that a fault can be represented by applying a voltage at the point of fault, whose magnitude is equal to that existing at this point before the fault and whose polarity is opposite to that of the voltage existing before the fault. When this voltage is applied and all other voltage sources are short-circuited, all currents caused by the fault can be found.

The division of the total motor reactance between the parts of a motor winding can be determined on the basis of two ideas. First, the sum of the reactances of the parts of a motor winding and the mutual reactances between these parts must add up to the effective motor reactance. Second, there are two limiting ways that motor reactance can vary with the fault location. One extreme is that the reactance is directly proportional to the number of turns in each part of the motor windings. The other extreme is that the reactance is directly proportional to the square of the number of turns. The first extreme says that there is no coupling between the parts of the motor winding; the second extreme says that there is perfect coupling between the parts of the motor winding. An average value of coupling between these extremes, as well as a reasonable value of coupling, is used in calculating the current magnitude over a wide range of fault conditions.

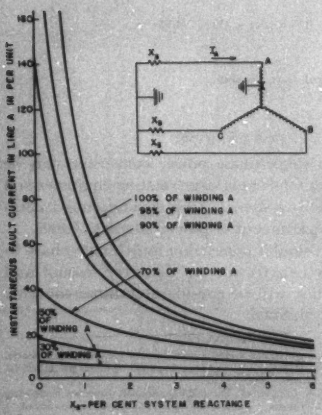


Fig 1. Line-ground fault, solidly grounded system single-circuit motor

Quantitative answers to the question of magnitude of fault current show the relative importance of the seven factors that determine the magnitude of short-circuit current. Fig. 1 illustrates this type of information and shows the effect of system reactance on fault-current magnitude for a line–ground fault on a solidly grounded power system.

SUMMARY AND CONCLUSIONS

CURVES and calculations provide a general answer to the question of the magnitude of current for internal faults in a-c motors for the purposes of evaluating protective devices. Fault location and size of the grounding resistor determine the fault current on a resistance grounded system. Both the initial and steady-state value of fault current are approximately the same. The following conclusions apply to solidly grounded systems and ungrounded systems: (1) the current is very high when the fault is located near the motor line terminals and decreases considerably as the fault location point is moved toward the neutral point; (2) the system reactance is the important factor for high-current faults; (3) the motor reactance and the number of motor circuits are the important factors for low-current faults; and (4) after a few cycles of time, the fault current may decay to a very low value.

All parts of the delta-connected motor winding are above ground potential and the instantaneous line current produced by a ground fault is always several times as large as the motor rated current. The line fault current for a wye-connected motor is less than rated motor current for faults located near the neutral. However, even on a wye-connected motor, protective devices operated by the ground fault current (and not line fault current) would be able to detect a ground fault located only a few per cent of the winding away from neutral. Curves were calculated primarily for induction motors, but curves and conclusions would also generally be applicable to synchronous motors.

Digest of paper 56-259, "Calculation of Fault Currents for Internal Faults in A-C Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

R. A. Schmidt is with General Electric Company, Schenectady, N. Y.

Electrical Resistance to Earth of a Tree

F. M. DEFANDORF
FELLOW AIEE

LIVE TREES are frequently struck by lightning with varying degrees of injury, from bark wounds that may heal so well in a few years that unnoticeable scars are left—to splitting and shattering of the trunk or extreme blasting of the bark, that results in early death of the tree. It is well known in high-voltage laboratories that extremely dry wood is none too reliable for use in surge voltage demonstrations where, as a stunt, one wishes to split wood by means of a high-voltage surge discharge. It was thought that the electrical resistance characteristics of a live tree might play an important role relative to lightning damage. Because values of the electrical resistivity of green (live) wood were not found in a library, it seemed that it might be worthwhile to make measurements on trees adjacent to and similar to a tulip tree, about 100 feet tall, that had been almost mortally wounded by a lightning stroke.

Although measurements of resistance were made on several species of trees, particular attention was directed to several sizes of tulip trees. Measurements were made, using instruments of the megger-type on leaves, from the tip end to the base of a leaf stem; on twigs, branches, and trunks; and from the base of tree trunks to an electrical ground. The resistance features of a tree 80 feet high (25 meters) were then constructed from these measurements of resistance and computed resistivities, using as a model a tree having diametral measurements along its length corresponding to measurements on a felled tree. Fig. 1 gives a synthesized representation of the electrical resistance features of a tree.

In connection with the measurements, it is of interest that the average longitudinal resistivity of green tulip wood, having a moisture content about 60 per cent of dry weight (0 per cent moisture), ranged from the order of the resistivity of Washington, D. C., tap water, 5,000 ohm-cm, to two and one half times higher. Measurements were also made of the decrease in resistance of sections of a tree limb with increase in temperature. The resistance was found to drop by a factor of nearly 10, on heating from room temperature to slightly below the boiling point of water. There seemed to be a low-temperature cooking effect, as the initially higher resistance was not recovered on cooling to room temperature.

Dead outer bark is fairly good insulation until wetted. The moist inner live portion of bark often shows less than half the resistivity of the adjoining interior wood—probably the reason that frequently the bark only is blasted by lightning. Live wood is significantly higher in resistivity in the radial direction, and in the circumferential direction may have 20 or more times the longitudinal value.

Digest of paper 56-627, "Electrical Resistance to the Earth of a Live Tree," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Scheduled for publication in the AIEE *Power Apparatus and Systems*, 1956.

F. M. Defandorf is with National Bureau of Standards, Washington, D. C.

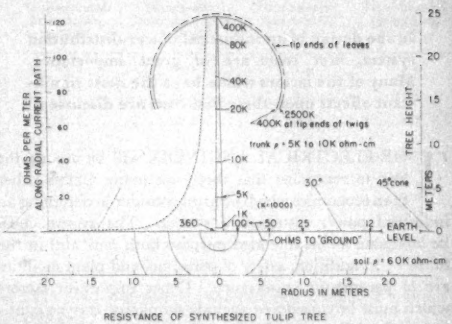


Fig. 1. Resistance of synthesized tulip tree. At earth level up the trunk, and to the tip ends, values are marked to show the ohms to "ground." On the left side of the trunk a dashed line shows ohms per meter along a radial current path, based on the measurements of ohms to ground made at various radial distances from a tree with the trunk as one electrode connection.

Samples taken along a radius show lower resistivities for outer and inner locations than for those in between for sound green wood.

An examination of the volt–ampere relations for current in the lower and upper portions of a tree trunk, as compared with volt–ampere characteristics for an arc in air, reveals that for low values on increasing current, as in a surge or lightning discharge, the tree trunk initially offers a better path on the basis of lower voltage drop per unit length of an arc in air. At somewhat larger values of current, considerably in excess of 5 amperes, an arc in its steady-state, because of its remarkable volt–ampere characteristic, becomes an equally good or even better conductor than the green wood of a tree. Should ampere–time characteristics of the discharge be suited to raising the wood temperature, one might well expect the negative temperature coefficient of resistance of green wood to come into play, so that the current would become concentrated along one or more paths. The resulting effect of increased local heating should afford increasingly lower conductivity, presumably until temperature and pressure conditions are reached, that are suitable for conversion of the moisture and solid conducting components into gases. Whether or not the effect is burning of the fibers, partial or complete rupture of the wood and bark, or merely a transfer of the discharge of an arc outside the tree trunk to air depends largely on the particular meteorological conditions that lead to the lightning stroke to the tree. Trees are injured by lightning more often than is generally realized; as their trunks are of greater diameter, they are therefore so much better conductors than their upper branches.

Economics of Distribution Systems

P. F. LARSON
ASSOCIATE MEMBER AIEE

In the design of an industrial power distribution system, first costs are of great importance. Many of the factors which have the most significant effects upon these first costs are discussed.

THE ELECTRICAL ENGINEER will be among the first to recognize that there are many factors other than economics which he must consider in designing an industrial power distribution system. The system must be adequate for its intended purpose both now and in the future. In addition, safety of personnel and plant facilities are of paramount importance. Other important factors which must be considered include simplicity, service continuity, flexibility, regulation, efficiency, operation, and maintenance.

The simple system not only costs less to build than a more complex one, but it also usually is easier to maintain. This, in turn, can contribute to service continuity. A power system must provide a reasonable degree of continuity of service or it is no bargain. The wasted man-hours and lost production which can result from power interruptions may cost thousands of dollars. Any industrial power distribution system should have reasonable provisions to permit changes in plant layout or operating plans. Permissible variation of voltage may be greater or less than normal. Each of these design considerations affects the investment which will be required by the power system.

The relationship between economic considerations and all of the other factors involved are things which the engineer must study as an important part of his professional responsibility.

There are many simple relationships between service requirements and construction costs that are well known and generally accepted. For instance:

1. The radial distribution system is usually the most economical for industrial plants. Often it will provide the required service continuity with no sacrifice to safety or simplicity.
2. Primary and utilization voltages selected will affect system costs.
3. Size and location of power load centers will affect system costs.

There are, however, many design considerations in which the effect upon total construction cost is much less evident. The owner usually wants, expects, and is entitled to an answer to the questions: "What type of power distribution system shall I use?" and "How much will the power distribution system cost?"

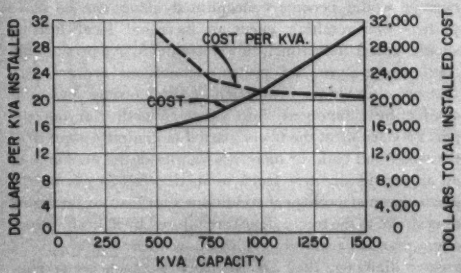


Fig. 1. Total installed power load center costs.

RELATIVE ECONOMICS

IN ORDER TO EVALUATE the relative economics of various industrial plant distribution systems, the following steps are necessary:

1. Determine the magnitude and location of loads to be served.
2. Determine the primary voltage.
3. Determine secondary utilization voltages.
4. Determine preferred and alternate transformer capacities and locations.
5. Prepare preliminary single lines and plans of systems to be considered.
6. Determine estimates of the installed cost of system components, such as primary service switchgear, primary disconnect or selector switches, primary distribution switchgear, primary feeders, transformers, main secondary breakers, and differences between secondary feeders to load centers.

The unit cost charts shown in Figs. 1 through 3 may be helpful in preparing preliminary plans and estimating construction costs. All of these are based on total current installed costs in January 1956, including material, labor, and contractors' overhead and profit.

Fig. 1 shows the total installed cost for power load centers consisting of unfused primary disconnect switch, 11.5-kv to 277Y/480-volt transformer, and main secondary breaker for transformers of various capacities, as well as the total installed cost per kva.

Fig. 2 shows the total installed cost per foot, and per thousand kva capacity per foot, for 11,500-volt and 4,160-volt primary feeders. Costs are based on three rubber-insulated shielded single conductors in rigid conduit. Current-carrying capacities and conduit sizes are based on the 1953 National Electrical Code.

Full text of paper CP56-718, recommended by the AIEE Committee on Industrial Power Systems for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956.

P. F. Larson is with Holmes and Narver, Inc., Los Angeles, Calif.

Fig. 3 shows the total installed cost per foot, and per hundred kva capacity per foot, for 480Y/277-volt and 120/208-volt secondary feeders. Costs are based on four *RH–RW* single conductors installed in rigid conduit in accordance with the National Electrical Code.

Tables I and II tabulate the results of such preliminary planning and economic analysis for a typical industrial plant of approximately one million square feet.

Study of Figs. 1 through 3 and Tables I and II reveal many interesting relationships between design considerations and construction costs. It should be kept in mind that although the principles will be true, in general, the estimated costs shown in Table II apply only to the particular plant. It should also be noted that percentage figures of system cost refer only to the portion of the system which was considered in the analysis and do not include the cost of complete secondary distribution.

Table I. Preliminary Estimated Electrical Construction Cost Apportionment

1,000,000-SQUARE-FOOT INDUSTRIAL PLANT
January 1956

SYSTEM COMPONENTS	PERCENTAGE OF TOTAL COST FOR VARIOUS SYSTEM COMPONENT			
	12,050 Kva Basic Loop Primary, Truss-mounted Transformer, 11.5 Kv	12,550 Kva Alternative 1 Floor-mounted Transformer. Otherwise similar to Basic	12,050 Kva Alternative 2 Radial Primary, Truss-mounted Transformer, 11.5 Kv	11,300 Kva Alternative 3 Radial Primary, Truss-mounted Transformer, 4.16 Kv
1. Service Circuit Breakers	3.8	2.9	5.8	8.6
2. Primary Loop Feeder or Radial Feeders	16.4	15.0	9.9	13.9
3. Primary Loop Circuit Breakers or Main Fused Switchgear	22.9	27.2	5.2	4.1
4. Primary Fused Selector Switches or Disconnect Switches	9.2	10.9	6.9	5.3
5. Transformers	32.7	26.9	49.6	43.8
6. Main Secondary Breakers	8.0	7.0	12.0	13.6
7. Floor Area for Substation	5.0	7.3	7.6	7.3
8. Excess Secondary to Load Centers	2.0	2.8	3.0	3.4
TOTALS	100.0	100.0	100.0	100.0

Transformer costs approximate 27 to 50 per cent of the system ($14.30 to $17.40 per kva). These can be kept down by sizing transformers in the most economical range (saving $5 to 10 per kva), by choosing proper primary voltage (saving $2 per kva). Good maintenance of lighting may reduce transformer costs by $2 to $3 per kva.

Primary feeder costs approximate 10 to 16 per cent of the system cost ($3.40 to $10.00 per kva). These can be kept down by locating the transformers properly (saving $1.45 per kva), by using radial rather than loop (saving $4 per kva), by choosing the proper primary voltage (saving $1.16 per kva), and by sizing conductors in the most economical range.

Main secondary breaker costs approximate 7 to 14 per cent of the system cost ($4.15 to $4.65 per kva). Sizing transformers in the most economical range can save $0.27 to $0.50 and up per kva. Combining lighting and power on 277Y/480-volt systems can produce savings of another $2 per kva.

Primary disconnect switch costs approximate 5 to 11 per cent of the system cost ($1.75 to $7.27 per kva). These can be minimized by using the optimum number of transformers (saving $2.49 per kva), by using unfused disconnects rather than fused selector switches (saving $2.40 per kva), and by choosing proper primary voltage (saving $0.63 per kva).

Floor area for substation and power load center costs approximate 5 to 8 per cent of the system cost ($2.39 to $4.90 per kva). Locating these in the least expensive satisfactory space near load centers can save $2.27 per kva. Using primary voltage for large motors where practical can save an additional $0.24 per kva.

Primary circuit protection costs approximate 4 to 27 per cent of the system cost ($1.34 to $18.20 per kva). To reduce these, use the optimum number of transformers (saving $6.27 per kva), use fuses rather than circuit breakers (saving $4.35 to $10.14 per kva), and choose the proper primary voltage (saving $0.45 per kva).

Service circuit breaker costs comprise 3 to 9 per cent of the system cost ($1.91 to $2.38 per kva). In choosing the proper primary voltage it is possible to save approximately $0.84 per kva.

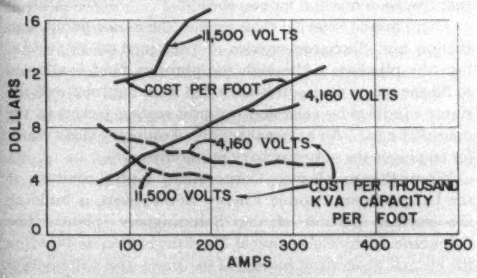


Fig. 2. Installed primary feeder costs.

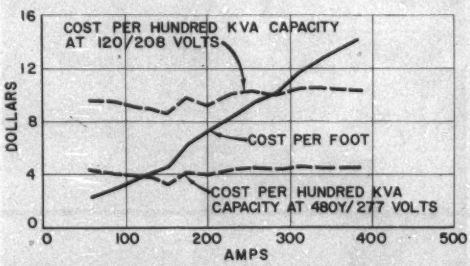


Fig. 3. Installed secondary feeder costs.

Excess secondary feeders to load centers cost 2 to 3 per cent of the system cost. These can be minimized by locating transformers near load centers (saving $0.86 per kva), and by using optimum feeder sizes.

Table II. Preliminary Estimated Electrical Construction Costs

1,000,000 SQUARE FOOT INDUSTRIAL PLANT
January 1956

SYSTEM COMPONENTS	12,050 Kva Basic (Loop Primary, Truss-mounted Transformer, 11.5 Kv)	12,550 Kva Alternative 1 Floor-mounted Transformer. Otherwise similar to Basic	12,050 Kva Alternative 2 Radial Primary, Truss-mounted Transformer, 11.5 Kv	11,300 Kva Alternative 3 Radial Primary, Truss-mounted Transformer, 4.16 Kv
	TOTAL INSTALLED COST			
1. Service Circuit Breakers	$ 24,000	$ 24,000	$ 24,000	$ 32,000
2. Primary Loop Feeder or Radial Feeders	103,000	125,700	41,000	51,500
3. Primary Loop Circuit Breakers or Main Fused Switchgear	144,000	228,000	21,600	15,200
4. Primary Fused Selector Switches or Disconnect Switches	57,600	91,300	28,800	19,800
5. Transformers	206,000	225,500	206,000	162,000
6. Main Secondary Breakers	50,000	58,400	50,000	50,000
7. Floor Area for Substation	31,700	61,500	31,700	27,000
8. Excess Secondary to Load Centers	12,600	23,900	12,600	12,600
TOTALS	$628,900	$838,300	$415,700	$370,100
	(170 per cent)	(226 per cent)	(112 per cent)	(100 per cent)

CONCLUSIONS

There are many factors which will affect the first cost of industrial power distribution systems, and many ways in which the electrical engineer can reduce the required initial investment. Consideration of factors other than economics of first cost may lead to the selection of components on the basis of value rather than price. It is necessary to study what and where the costs are in order to evaluate these factors. A method has been proposed for combining preliminary engineering and estimating work. Such studies should establish within reasonable limits where savings can safely be made in capital costs with due consideration to system safety, simplicity, service continuity, flexibility, regulation, efficiency, operation, and maintenance. These studies will also indicate what the approximate magnitude of these savings may be.

Largest "Canned" Motor Pump on Test

This 1,600-hp Westinghouse Electric Corporation "canned" motor pump shown on test is the largest which has ever been built. The first of three main coolant pumps the company is building for the 60,000-kw pressurized water-cooled reactor located at Shippingport, Pa., it has been undergoing rigorous performance tests since June 1955.

The hermetically sealed zero-leakage motor pump will circulate 18,300 gallons per minute or more of radioactive water through the primary loop of the reactor at approximately 2,000 psi (pounds per square inch), and 500 F. Pressure rise across the pump at design point is 115 psi. The pump uses a 1,200-kw 2,300-volt single-winding motor that can be connected for two speeds.

There are no external shaft seals in the motor pump, and suction and discharge nozzles are designed to be welded into the pipeline. Although the pumped fluid is allowed to fill the motor cavity, it is excluded from the rotor and the stator windings by corrosion-resistant sealing jackets in the magnetic gap. An external supply of ordinary clean water for cooling is the only auxiliary requirement.

Westinghouse Electric Corporation, under contract to the United States Atomic Energy Commission, is building the nuclear portion of the Shippingport plant. The Duquesne Light Company of Pittsburgh, Pa., is building the electric generating portion of the plant and will operate the entire station, which is scheduled for completion in 1957.

Corrosion of Insulator and Conductor Hardware

A. W. BARDEEN J. M. SHEADEL
MEMBER AIEE

WET-PROCESS PORCELAIN as used for high voltage insulators is well known for its ability to resist atmospheric corrosion. Insulator assemblies and associated fittings usually include hot-dip galvanized ferrous metal parts which have satisfactory corrosion resistance for normal service requirements. In industrial and certain coastal areas, however, the contaminated atmosphere increases the corrosive attack and shortens hardware life.

The rate and type of attack depend not only on the atmospheric conditions and the kind of metal, but also on electrostatic overstress which may occur at critical points. The initially formed corrosion products also influence the rate of attack. Tightly adherent compounds serve as a retardant to further corrosion, but loose and flaky material tends to harbor moisture and to expose new metal surfaces.

Examination of corroded metal parts suggests six classes of corrosion for insulator and conductor hardware:

a. The most common class, loss of section of exposed metal, usually occurring in a contaminated, acid atmosphere, often with frequent rainfall. Enough metal may be lost so that mechanical strength is reduced to a critical value. This may be controlled by additional metal sections, cathodic protection, and changes metal composition.

b. Corrosion of insulator hardware may not halt at assembly joints but may continue to attack the surface of metal within the assembly when insulators are subjected to an unusual combination of exposure and voltage stress. Under these conditions hard radial struts of iron oxide develop at the steel insulator pin. In time, these struts extend into the pinhole, exert a bursting pressure and cause radial cracks in the insulator porcelain. Use of stainless steel or silicon bronze pins will markedly increase the insulator service life.

c. Corrosion of insulator hardware inside assemblies with little external attack is found rarely. In a few coastal areas, a prolonged and recurring damp atmosphere, insulator surface contamination and electrostatic overstress forming ozone may lead to corrosion inside the assembly by oxygen concentration cell action. When a steel insulator pin is affected, the hard corrosion products confined in the pinhole may cause sufficient mechanical stress to crack the insulator. This class of corrosion has been controlled by the use of stainless steel or silicon bronze insulator pins.

d. Stress corrosion cracking may occur when vulnerable alloys are subjected to an unfavorable combination of tensile stress and corrosion. Surface coatings or heat treatment may sometimes be beneficial but a preferred solution is the use of an alloy not susceptible to stress corrosion.

e. Galvanic corrosion appears when dissimilar metals in electrical contact are in an electrolyte. This may be minimized by surface coatings, large anodic areas and intelligent use of metals close together in the electromotive table.

f. Insulating films of corrosion may affect the performance of conductor suspension clamps or of suspension insulator connecting hardware. The initial corrosion of aluminum or galvanized ferrous hardware surfaces develops a thin film of oxides or carbonates which, when dry, has high electrical resistance. Power arc current passing through this film at a low pressure contact between the conductor and a suspension clamp may cause overheating and burning of the conductor. The use of clamps with U-bolts to increase pressure has proved to be a solution. At lightly loaded suspension insulator string connections enough voltage may develop across insulating films to cause a localized arc and radio or television influence. This effect may be relieved by petroleum-base coatings, low-resistance paint, an increase in contact unit load or a bond across the connection.

A recognition of the corrosion problem affects the design, choice of materials, application and maintenance of insulator and conductor hardware. Favorable control measures include (a) hardware designs with smooth contours and large radii to reduce voltage stress, (b) cathodic protection as provided by hot dip galvanized or hot dip aluminum coatings, and (c) use of materials having improved corrosion resisting properties. Malleable iron generally resists atmospheric corrosion more effectively than carbon steel. Use of low-alloy steel in place of mild steel for insulator pins is under test at laboratory and service locations. Stainless steel and silicon bronze may be specified for insulator or conductor hardware where severe corrosion justifies the expense and where adjoining metals are compatible.

Coating the insulator and hardware surface with long-life petroleum-base greases is a maintenance procedure which may be justified in certain areas. Not only is the hardware surface protected from the atmosphere, but the grease on the insulator surface will help prevent the formation of an electrolyte. This reduces the possibility of leakage current surges, electrostatic overstress, and the formation of corrosive ozone.

Corrosion of insulator and conductor hardware will vary with the concentration and kind of pollution, degree of rainfall, wind direction and velocity, amount of voltage stress, and other atmospheric conditions such as humidity and temperature. For any exposure, field tests with energized specimens are necessary to confirm corrective measures.

Digest of paper 56-230, "Corrosion as It Affects Insulator and Conductor Hardware," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

A. W. Bardeen is with the Ohio Brass Company, Mansfield, Ohio; J. M. Sheadel is with the Ohio Brass Company, Barberton, Ohio.

Useful Applications of a Magnetic-Drum Computer

STANLEY FRANKEL

The general applications and the operation of magnetic-drum digital computers are described by use of a detailed explanation of the LGP-30, a typical example of this class of computers.

ONE of the most useful and flexible types of computer in current use is the magnetic-drum digital computer.

The range of suitable applications for this type of computer is explored in this article. The Librascope, Inc., type *LGP-30* computer (Fig. 1), here used as a typical example of magnetic-drum computers,[1] is described in sufficient detail to explain its elementary operations and to demonstrate how these elementary operations can be combined to perform complex computations. It is not possible to present a precise definition of the class of problems to which these machines can usefully be applied. Instead, these problems will be sketched in broad outline, as a part of the more clearly definable class of problems which can, in principle, be solved by machine computers.

In approaching the problem of useful applications of drum computers, we first ask the broader question, "What tasks can be performed by any digital computer, without regard for speed, convenience, or economy?" It is convenient to consider together the human computer (equipped for example, with a standard desk calculator) and the machine digital computers. We thus ask, in brief, what is a *computation*? Computations of the most familiar type are straightforward sequences of arithmetic operations. An example is the evaluation of the entries in a mathematical table. It should be noted, however, that neither the mathematical analysis leading to a formula for the function nor the printing of the final volume is included in the customary meaning of *computation*.

There are other operations, also called computations, which are not so clearly of arithmetic character. One example is the process of sorting a set of words into alphabetic order. This example still has a somewhat arithmetic character since the alphabetic ordering of words can easily be represented by a *greater than–less than* relationship of numbers. A more clearly nonarithmetic example of computation is the translation of prose from one language to another. It now seems to be possible to perform this task usefully, if not with great literary merit, by machine.

The common feature of these computations is that a body of information is somehow transformed or manipulated. The output resulting from a computer's activity is information, numerical or otherwise. Similarly, the computer requires an input of information which is transformed into the desired output. Not all of this input information is numerical in the ordinary sense; another part is a set of instructions which control the activities of the computer. There may not be a sharp distinction between these two types of input.

Often instructions are presented to a computing machine in a numerical code so as to standardize the way in which it receives and holds information. In the early digital computers, and in some designed for special purposes, much of the instructional information is set into the machine by wiring, either permanent or replaceable. In the modern "general purpose" computers most of the instructions are introduced in numerical guise and look much the same as the data to be operated upon.

Instructions given to a human computer must be fairly complete. Some instructions may be implicit; that is, they have been supplied to him previously. For example, he might know a procedure for extracting a square root. He would not, however, be expected to invent such a procedure. A machine computer needs even more complete directions. It must be instructed in every detail of the intended operation. This instruction is, in part, supplied in the construction of the machine and, in part, in the instructional input for the particular job. It can never be told, "Use your own judgment." To make the discussion uniform, we may similarly restrict the definition of a human computer; when he responds to such a vague directive he is not functioning as a computer but in some other capacity.

The description can now be sharpened as follows: A computation is the transformation of a body of information. Its output is completely determined by its direct input together with the well-defined rules of operation of the computer. A computer can transform but cannot produce information. In the recently developed theory of communication, there appears a close analogy with thermodynamics. Information plays a role like "negative" entropy. In a computation, information can be, and usually is, lost; no information can be created. This seems to cast doubt on the usefulness of computers. If each transaction may show a loss but never a gain, where is the profit? However, the *amount* of information as defined in communication theory is not the only measure of its utility. Some computations present information in a more useful form by expansion. Thus, a harried navigator finds more comfort in a table of haversines than in a succinct formula which implies all the numbers in that table and infinitely many

A special article recommended for publication by the AIEE Committee on Computing Devices.

Stanley Frankel is a consultant to Librascope, Inc., Glendale, Calif.

more besides. In other uses, a computer refines a large mass of data into a smaller but more useful summary. The computer may then be likened to a smelter yielding a compact body of virgin metal which commands a higher price than the gross ore.

The ability of a computer to transform instructions and primary data into a desired set of consequences has been well described as follows: "The Analytical Engine has no pretensions whatever to *originate* anything. It can do anything we *know how to order it* to perform. It can *follow* analysis; but it has no power of anticipating any analytical relations or truths."[2]

The output of a computation can be regarded as the solution to a problem posed by the input. The problem may be a trivial one, such as a test problem which is run to see if the computer is behaving properly, but still it is a problem to the computer, if not to the operator. Roughly speaking, the value of a computer is indicated by the extent of the set of problems it can solve. Here we must distinguish a solution from a mere answer: whatever the input, the computer will "answer" by doing *something*, but that answer may not be a solution to the problem the operator has in mind. Not every problem can be solved by a computer; in fact, some problems have no solutions. More precisely, we should say that there is no way of putting these problems to a computer which will produce as output a satisfactory solution. We are not concerned here with the difficulty in finding a way of posing a problem. That is a matter of the ingenuity of the user. We ask only whether or not the required solution can result from *any* input to the computer. In particular, we are led to ask about the class of problems which can be solved by a "best possible" computer.

This question was discussed by A. M. Turing in 1936.[3] He describes a computer as a "black box" of finite complexity; that is, one capable of existing in a finite set of states. It operates on a finite body of information, its input, initially recorded on its memory unit which has indefinite capacity. It will be seen later that this is a very practical idealization of existing digital computers. The output of the computer, the answer to its problem, is an indefinite series of digits reported out in the course of its operation. By regarding these digits as the expansion of a real number, we may think of the answer to any computational problem as a single real number. A number which could be produced in this way by any possible computer is called a "computable number." The set of all solvable problems is thus represented by the set of all computable numbers. It is a consequence of the required finiteness of the complexity of a computer and of its input that the computable numbers form a merely denumerable set. (Thus most numbers, or in the language of measure theory "almost all" numbers, are noncomputable. It is, nevertheless, quite difficult to produce an example.)

One remarkable result of Turing's investigation is that he was able to describe a single computer which is able to compute *any* computable number. He called this machine a *universal computer*. It is thus the "best possible" computer mentioned.

The machine described by Turing is able to hold in its memory a suitably coded description of an arbitrary computer together with its input, and is able to simulate the behavior of that computer. For any solvable problem a particular computer could be described which solves it. By simulating that particular computer, the universal computer can also solve that problem. Thus, the universal computer is able to solve any solvable problem. This surprising result shows that in examining the question of what problems are, in principle, solvable by computing machines, we do not need to consider an infinite series of computers of greater and greater complexity but may think only of a single machine.

Even more surprising than the theoretical possibility of such a "best possible" computer is the fact that it need not be very complex. The description given by Turing of a universal computer is not unique. Many computers, some

Fig. 1. The LGP-30 computer, including a Flexowriter as input-output device.

of quite modest complexity, satisfy the requirements for a universal computer. In particular, it will be seen in the following that any of the modern general purpose computers, such as the relatively simple *LGP-30*, is a universal computer, as is the "Analytical Engine" mentioned previously.

We now have a partial answer to our question as to the range of problems which can, in principle, be solved by a general purpose computer (GPC); namely: What one GPC can do so can another. This statement has to do only with what problems a GPC can, in principle, solve; leaving aside such practical considerations as speed, cost, and reliability. Naturally, the utility of a GPC for a particular application depends on its ability to produce reliable results quickly and cheaply as compared with competing computers both human and machine. In the following sections, the structure and mode of operation of the *LGP-30*, as an example of drum computers, will be described in some detail. It can then be seen in what ways these practical considerations restrict the range of problems to which the drum computers can usefully be applied.

THE FUNCTIONAL DESIGN

THE CHIEF MEMORY DEVICE of the *LGP-30*, like other drum computers, is a "magnetic drum." This is a rotating cylinder having a magnetizable surface on which information can be recorded in much the same way as music is stored by a magnetic tape recorder. The body of information stored in the memory of a GPC is usually held as a set of segments, each of which can be "read" and brought into active participation in the computation as required. The instructional information usually consists of a series of elementary instructions which are read and obeyed one after another. For example, a typical instruction in the *LGP-30* calls for the performance of an arithmetic operation on two numbers. One of these numbers is selected out of the body of numerical information in storage by designating the memory "location" in which it is held. The other number used in the operation is that which is held in a specialized memory device called the accumulator. At the end of the operation, the result is retained in the accumulator. The accumulator consists, in part, of two heads close to the rotating drum in the same circumferential track, together with associated electronic equipment. These two heads and a third, which is discussed later, are shown in Fig. 2. The first head records on the magnetizable coating of the drum a sequence of (binary) digits. Each digit is, at a slightly later time, read by the second head and presented to the active circuitry of the computer. During some phases of activity, digits are recorded by the first head exactly as they are presented by the second head. This leads to the recirculation of the sequence of digits held at any one moment on the magnetic coating of the drum between the two heads. For this reason the accumulator is called a circulating register.

Fig. 2. The recording and two reading heads of the accumulator.

To prevent progressive deterioration of the quality of recording, it is necessary to sharpen and "retime" the recorded digits with each recirculation. Another track of the drum is used to provide the basis for this retiming. On this sprocket track there is a permanently recorded periodic signal which is read by a head, amplified, peaked, and presented to the active circuitry as a regular sequence of *clock pulses*. The interval between two consecutive clock pulses is called a *digit period*. A digit period occupies about 8 microseconds. In each drum revolution (occupying about 16 milliseconds), there are 2,048 digit periods. At each clock pulse, the amplified output of the accumulator reading head is sampled and used to set a *toggle* (i.e., a flip-flop, a bistable multivibrator) either to its "zero" or to its "one" state. This toggle holds and presents the binary digit so read during the succeeding digit period. This binary digit (bit) is recorded by the accumulator recording head during that digit period if simple recirculation is required. The distance between the recording and reading heads of the accumulator is such that the period of recirculation is 32 digit periods; in other words, 1/64 of a drum revolution.

Three other permanently recorded timing tracks produce various pieces of timing information. One of these is a signal which distinguishes every 32-digit period, called a *sign digit period*. A group of 32 consecutive digit periods ending with a sign digit period is described as a *word period*. Similarly, the 32 digits presented by any part of the computer during a word period are called a *word*.

The word presented by the accumulator usually represents an algebraic number by the following system of interpretation: The first digit is a *spacer bit* of no numerical significance. (It is always recorded as a zero.) The second digit presented has the numerical value 2^{-30} if the digit is 1, otherwise 0. The third digit presented contributes the numerical value 2^{-29} or 0. This progression continues up to the 31st digit which contributes the numerical value 1/2 or 0. However, the final digit, presented during the sign digit period, does not have the numerical value 1 or 0, but rather the value -1 or 0. This permits representing both positive and negative numbers.

The main memory of the *LGP-30*, usually called simply the *memory*, is held on 64 tracks of the drum, each with an associated head. Any one of these heads can record information on its track or read from it information previously recorded, though not both simultaneously. Only one reading circuit and one recording circuit is provided for the memory. Which one of the 64 heads is connected with these circuits is determined by the settings of six P-toggles, In reading from the memory, the selected head sets a toggle, V, in each digit period. Toggle V presents, in succession, the 2,048 bits previously recorded in that track. These bits form the 64 words of 32 bits each held in that track.

The particular word of the memory to be used in an operation is singled out in two steps: First, by setting the P-toggles, the required track is selected. Then, after waiting an appropriate number of word periods, the desired one of the 64 words in the selected track is ready to come under the head in the word period in which the operation is performed. The desired word (or, more precisely, the memory location in which it resides) is designated by its *address*. An address consists of two (6-bit) numbers, each having the range 0 to 63. One, the *track number*, indicates the track to be selected. The other, the *sector number*, selects the required word of that track. In most operations, some one memory location is selected and sought out in this way. In a *record* operation a word, or part of a word, is recorded on the selected track during the word period of execution. Each instruction includes an address, its *operand address*, designating the memory location to be selected.

The *LGP-30* has two other circulating registers, besides the accumulator, each having a recirculation time of one word period. One of these is the *counter*. Its primary purpose is to hold the address of the memory location in which will be found the next instruction to be obeyed. After an operation has been completed the memory location designated by this *control address* is sought out in the same way as an operand memory location is sought. The word found at the control address is read into the third circulating register, the *instruction register*, where it is held for as long as is required for it to be acted upon as an instruction.

An instruction word has two parts, an order and an address. Four bits describe the order, indicating the kind of operation to be performed. Six bits indicate the sector number and six more the track number of the operand address. By reason of this structure of an instruction the *LGP-30* is said to have a *one-address code*.

After an instruction word has been located and set into the instruction register, the control address, held in the counter, is augmented by one to prepare for its next use. (In the normal course of events, instructions are read and executed from consecutively addressed memory locations.) Thereafter the content of the counter usually recirculates without change until after the next reading of an instruction word. However, if an instruction is an effective *control transfer instruction* its execution consists of the transfer of the content of the instruction register into the counter. This produces a deviation from the normal sequence of instruction locations described in the foregoing.

After an instruction has been set into the instruction register, it is held there until several activities are completed. During the next word period, the order part of the instruction is set into four Q-toggles and the track number of the operand address is set into the P-toggles to prepare for the reception of the operand word. The operand sector number usually cannot be disposed of summarily. In succeeding word periods, this sector number, recirculating in the instruction register, is compared with a synchronously presented announced sector number, provided by the timing tracks. Each of the 64 sector numbers is announced in one of the 64 word periods of a drum revolution. The sector numbers are not announced in numerical sequence but in accordance with an *interlace pattern* described later. Agreement, between the announced sector number and that recirculating in the instruction register, marks the end of the period of search. In the following word period, the operation is performed or, if the operation is a multiplication or division, commenced. After this agreement has been found, the instruction need no longer be held in the instruction register. Accordingly, this register is used, on multiplication or division, to hold for later use the operand word (the multiplicand or divisor) which is set into it in the following word period.

THE ELEMENTARY OPERATIONS

THE 4-BIT ORDER CODE used in the *LGP-30* permits the use of 16 elementary operations. All of the 16 order codes permitted by the code structure are used. Some of these orders may be explained as follows:

The order, *extract*, is used to isolate selected portions of a word, replacing all digits of the remaining part by zero. It can be used in packing several discreet brief pieces of information into one word and later separating them for individual use. This may be desirable for economy of information storage or because the separate pieces of information are closely related in a way which makes it convenient to handle them together, e.g., a month, day, and year which together specify a date. Another use for *extract* arises in the use of a function table stored in the memory. If an argument for this function is determined, in the course of the calculation, it may be used to get a value from the table by arithmetic manipulation and abridgment by the use of *extract*, thus forming an address to be set, say, into a *bring* order. Similarly, the remainder can be separated for use in an interpolation. An address which has been produced by arithmetic processes and by use of the *extract* order can conveniently be set into an instruction by use of the *y* order.

In multiplying, the accumulator is extended to double length by the use of an additional reading head which is spaced 33 digit positions beyond the first reading head. This extension gives space for a complete product consisting

Fig. 3. The control console of the LGP-30 and the oscilloscope display of the contents of the circulating registers.

of a sign and 60 digits. After completion of the multiplication, the normal accumulator recirculation in one word period is resumed; hence, only part of this complete product can be retained. For the order *M*, the more significant half is retained, the sign and 30 bits. For the order *N*, the less significant half of the product digits are retained.

Information is set into the *LGP-30* with the help of a Flexowriter, a punched paper tape controlled typewriter. A previously prepared tape may be used to set information into the accumulator, from which it is later transferred to an appropriate memory location under the control of the computer. In the *input* process, four digits of a tape symbol are inserted into the accumulator the previous content of the accumulator being moved "upward" to make room.

The conditional control transfer order, *test*, is used to introduce a "branching" of the sequence of instructions, contingent on the results of prior computation. It may, for example, be used in computing a function by successive refinements. After each refinement is completed, some measure of error is computed and subtracted from a preassigned tolerance value. A test order will then return control for another cycle of refinement if this difference is negative, showing that the error is intolerable, otherwise go on to further operations.

The conditional stop order, *Z*, helps in finding the errors in a malfunctioning "program." It may stop the computation, depending on the settings of several switches and of the P-toggles, set by the track number part of the address. The address has no other significance. By scattering *Z*-orders with various track numbers in the program (the sequence of instructions), the operator is enabled, by setting switches, to stop the computation at a point of his selection. Then by use of the one-operation mode he is able to go through the following part of the computation at a slow rate. In the one-operation mode, the computer, when started by a push-button, reads and obeys one instruction and then stops. The contents of the three circulating registers are constantly displayed on an oscilloscope to facilitate checking. This oscilloscope display of the registers, together with the operator's "console" of the *LGP-30*, is shown in Fig. 3.

Output also used the Flexowriter, which is then controlled by the computer. The order *print* causes the Flexowriter to type one symbol (or to space, carriage return, shift case, etc.) and, if desired, to punch that symbol on a paper tape. The effect of a *P*-instruction is determined by the track number part of its "address." There are, thus, 64 different print orders which may, by suitable programming, be used to produce any record which the Flexowriter is equipped to type. They may also be used to record results on tape in a form which permits it to be reinserted in the computer at a later time.

The ability of the *LGP-30* to punch intermediate results on a tape which can later be reinserted for further use gives it, in effect, an infinite memory capacity. The use of this auxiliary storage medium seems not entirely automatic since an operator is required to handle the tape. We may, however, think of the operator as acting under instructions supplied by the computer. (It is, for example, perfectly feasible to include in the program provision for typing out instructions to the operator in clear English.) It is in this sense that the *LGP-30*, which like any other general purpose computer has only a finite *internal* memory capacity, may be regarded as a universal computer.

SPEEDS OF OPERATION

In several drum computers, including the *LGP-30*, a drum revolution occupies about 17 milliseconds. Since executing an order requires first awaiting the appearance of the instruction, and then of the operand word, a typical time per operation would be in the tens of milliseconds. Several devices are used in drum computers to reduce this mean operation time. In some, such as the International Business Machines Corporation (IBM) *650*, a considerably higher drum speed is used. In some, like the Datatron, a part of the memory is held in recirculating loops which have shorter mean "access times." In the *LGP-30* another device is used, the aforementioned interlace pattern. Memory locations are so spaced around a track of the drum that eight word periods elapse between the presentations of two consecutively numbered words (in particular, two consecutively obeyed instructions). Problems may be so planned that the operand word usually appears in one of the middle six of these word periods. Planning a problem in this way is called "minimum latency coding." By exercising moderate care in coding, the mean time per operation in a typical problem may be brought down to about 4 milliseconds for the brief operations and 20 milliseconds for multiplications and divisions.

PROBLEMS SUITABLE FOR A DRUM COMPUTER

It has been argued in the foregoing that the class of problems which a drum computer such as the *LGP-30* can solve *in principle* is just the same class as for any other GPC, such as Charles Babbage's Analytical Engine referred to in the previously quoted statement. The statement, written in 1842 by Ada Augusta, the Countess of Lovelace, remains today an excellent description of the problems which can be solved by a Univac* *701*, or *LGP-30*. There remains the practical question, "What problems would it be *sensible* to present to a drum computer?"

As a partial answer to this question we can exclude two types of problems. At one extreme, there are computational problems which are too simple to justify the use of any automatic computer. If a calculation can be completed by hand in a few hours it is not likely to be worthwhile to devise a procedure for performing it on an automatic computer. Here we assume that this is a "one shot" calculation, not one which will be repeated many times with only minor variation. At the other extreme lie problems of such great computational difficulty that they cannot be completed in reasonable time by a drum computer. (It is assumed that such a problem is "all of a piece," i.e., it cannot be separated into parts which could be parceled out to many drum computers.) A classic example is the computation of tomorrow's weather on the basis of today's observations. The prediction will be useful only if it can be produced in less than a day. Some of these problems can be treated usefully by large-scale electronic computers which may have computing speeds several hundred times that of the drum computers. Others cannot reasonably be handled by any existing computers.

Between these extremes lies a broad class of problems which might sensibly be presented either to a drum computer or to a large-scale computer. (The two classes of computers have comparable speed-to-cost ratios.) In this range of problems several circumstances may favor the use of drum computers. One arises from the requirements of maintenance. The large-scale computers, by reason of their much greater complexity, may be expected to be subject to more frequent breakdown. It is also to be expected that a greater time will be required to track down and replace a malfunctioning component. This consideration bears most strongly on operations in which continuity of service is important. A single giant computer is more vulnerable to tube failure than an equivalent host of midget types.

For problems having considerable logical complexity but not requiring particularly great computing time, the drum computers have an advantage in the possibility of using the computer in checking out the program. In working through parts of a problem to find the origin of a difficulty,

* Reg. U. S. Pat. Off.

the greater speed of a large-scale computer is of no advantage. It usually is not economically feasible to use the large-scale computers in this way. The programmer can reasonably use a drum computer to assist in his part of the work, whereas an inexpensive man tends to become the slave of an expensive machine.

Drum computers have an evident advantage in small shop operations, where the work load is not sufficient to justify the presence of a large-scale computer. This is particularly true in places remote from service bureaus where the part-time use of a computer can be obtained. The same consideration applies to large but dispersed operations in which computing can be done more conveniently in many locations than in a central computing installation.

The discussion in the first part of this article showed that the class of "computations" is not one which can be narrowly described. A great variety of operations, arithmetic and otherwise, can be performed by computers. (As an extreme example, Turing examined the feasibility of sorting all possible mathematical assertions as true or false. This task, however, proved to be beyond the ability of even a universal computer.) In this section, an attempt has been made to indicate which problems are suitable for a drum computer by excluding broadly described classes. Some problems are too simple, some are too long for drum computers. In the following, a few examples of problems which are suitable for drum computers are displayed. They do not, of course, cover all of the uses now being made of drum computers, nor those uses yet to be found.

The preparation of a mathematical table typifies many problems in which a drum computer can be used to good advantage. Each step of the computation may be quite simple; for example, each entry in a table of exponentials can be obtained from the preceding entry by one multiplication. Almost all of the mathematical tables which have been published could now be produced quite expeditiously by drum computers—in most cases as fast as the results can be typed. For example, the excellent tables prepared by the Federal Works Agency of the Works Progress Administration in New York City could now be duplicated by an *LGP-30* at a rate of about one volume per day. Many business and accounting problems are of this type. The preparation of a large payroll by hand is a burdensome task even though each individual computation is of quite moderate complexity.

Some information-handling activities are difficult to carry out by hand by reason of the need for quick access to a great body of stored information even though no burdensome amount of arithmetic work is involved. Drum computers are beginning to be used for airline reservation reporting and other inventory reference problems. Probably many drum computers will be so used in the future. These machines tend to be specialized in having large internal memory capacity and many channels for input and output but have less arithmetic facility than other GPC computers.

Many tasks now being performed by computers previously went undone because of the great difficulty of doing them by hand. The recent development of "linear programming" and other methods of operations research is, in part, owing to the availability of computing machines. These techniques permit making many managerial decisions on the basis of calculation where formerly they could be based only on intuition.

Many problems involve the study of fields, electric, magnetic, acoustic, etc., which are governed by simple differential equations but are not analytically tractable. Some such problems which formerly could be treated only approximately, by field plotting methods and the like, can now be dealt with accurately and conveniently by drum computers. Others, of greater complexity, require the faster large-scale computers or are beyond the reach of any existing machines.

The techniques for preparing problems for solution by a digital computer, "programming" and "coding," are by now fairly widely known. Fortunately, the basic operations and abilities of the various GPC computers are very much alike, hence a person who has become familiar with the management of one computer can easily shift to another. For many computers, like the *LGP-30*, the elementary operations are suitable for a fairly straightforward translation from mathematical representation into the language of the computer. For example, the evaluation of $(ax+b)/c-d$ is fairly readily represented in the *LGP-30* code as *Ba*, *Mx*, *Ab*, *Dc*, *Sd*, where *a*, *x*, etc., are to be replaced by their addresses. The more sophisticated techniques required for efficient coding for each computer are fairly easily learned. Engineers only casually involved with the use of a computer can quickly pick up these skills, such as the use of minimum latency coding, or may disregard them for problems which do not make severe demands of computer time. Thus, the use of a drum computer should not be importantly limited by difficulty in finding or training its users.

REFERENCES

1. LGP-30 General Purpose Computer, **S. Frankel, J. Cass.** *Instruments and Automation*, Pittsburgh, Pa., vol. 29, 1956, p. 264.

2. Faster than Thought (book), edited by **B. V. Bowden.** Pitman & Sons, Ltd., London, England, 1953, p. 398.

3. **A. M. Turing.** *Proceedings*, London Mathematical Society, series 2, vol. 42, 1936, p. 230.

New Cancer Diagnosis Technique

Instruments being used in the development of the guidance equipment for the United States Air Force *SM-62* Snark missile are now aiding in the search for improved cancer diagnosis. New techniques in microscopy, more advanced than medical research has found, have been developed by Northrop Aircraft, Inc., Hawthorne, Calif. Particles as small as 10^{-12} gram can be chemically analyzed with adaptations in these techniques.

Using specially designed lenses and electronic circuitry, medical researchers are able to detect the smallest light variations produced in a specimen by the presence of infinitely minute particles of matter. The lenses are capable of being used even in the invisible sections of the spectrum.

INSTITUTE ACTIVITIES

North Eastern District Holds Successful Meeting in Rochester, N. Y.

THE NORTH EASTERN DISTRICT of the Institute held its three-day meeting at the Sheraton Hotel in Rochester, N. Y., May 2–4, 1956. Due perhaps to the inclement weather, the attendance was only about 350 members and guests, but the enthusiasm with which papers were received and discussed was in inverse ratio to the numbers attending.

Many members and guest attended the smorgasbord and the dinner dance. The four inspection trips were varied in interest and as might be expected in Rochester, two were photographic in nature: the George Eastman House of Photography and the Kodak Park Works of the Eastman Kodak Company. The Student Prize Paper Competition for the District was held on Friday morning, May 4.

General Session

The opening General Session started the program on Wednesday morning with C. G. Plomasen, general chairman, presiding. After welcoming the guests, he introduced G. R. Scofield, who, as the Rochester mayor's deputy, offered the freedom of the city to the members. The First District Vice-President, G. J. Crowdes, who was next introduced, remarked that district meetings were too infrequently held for the good of all concerned. He went on to say that the good leadership of AIEE in the field was unchallenged, and that the Institute's publications were a great assistance to the membership as a whole. He then introduced AIEE President M. D. Hooven, who thanked everyone for the warm welcomes which had been extended.

The chairman of the Rochester Section, H. A. Brown was then introduced and he in turn presented A. M. Beebee, president of the Rochester Gas and Electric Corporation, who gave the main address of the session, "Public vs Private Power—Which Is Right?"

The following points were developed by Mr. Beebee in his address:

Power from public power programs now serving some 12 per cent of the country, appears cheap only by avoiding taxes and other costs which all other areas must carry, and such tax loss must be made up by others. In the sale of the power they also give "preference" to certain groups who in the distribution of that power also avoid taxes.

There is no quarrel with the proposal that the people adjacent to large hydro developments should receive the benefit of electricity with no fuel cost in their power bills. Generally speaking, in most hydro operations that are economically sound, this saving represents some 15 per cent of the delivered cost of most electric service. However, in addition, these areas should not be allowed to avoid their fair share of the tax burden, and part or all of the interest and other charges which altogether total over 40 per cent of the normal price of electric service. These are costs which 88 per cent of the rest of the country must carry, and have nothing whatever to do with hydro power.

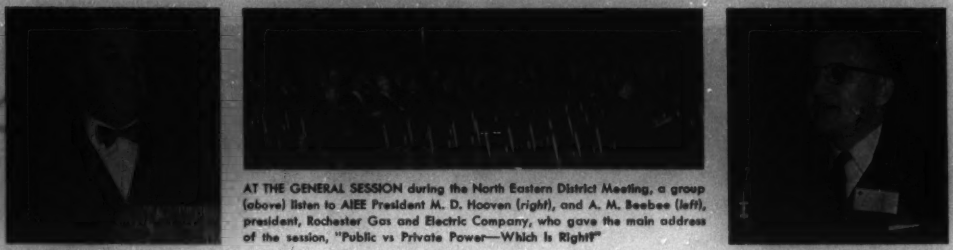
At the time many of these power programs were first proposed, taxes were low and every area tended to exist unto itself, and no great injustice was involved. Under present conditions, with modern transportation, each region now competes with others in the national market. Furthermore, taxes have increased enormously and represent a sizable portion of the cost of things.

Although the avoidance of taxes and interest in the power bills in certain areas may help those particular areas, consideration should be given to the "drowning" effect on all enterprise in the remaining 88 per cent of the country which must carry more than their fair share of the burdens. If tax avoidance is now extended further into fully developed regions, then every single state is entitled to do the same thing and the American way of life as we know it is on its way out.

If the United States is to grow and prosper it must have "equality of opportunity" and "equality of taxation." We must avoid having certain groups or areas avoiding their fair share of the tax burden and enticing industries from other part of the country and competing with their industries. Efforts are being made to correct the inequities that have developed as a result of public power programs in the Pacific Northwest and in the Tennessee Valley Authority. However, the time to correct such a situation is before it is started, not after it has become woven into the economic fabric of the area. It is for all these reasons that public power programs should be stopped dead in their tracks while they represent only some 12 per cent of the country. Now that these areas are no longer undeveloped, they should gradually be required to carry their fair share of the tax burden.

Development of power under private enterprise treats everybody the same, and since the industry is regulated in the public interest by

Above, left: A group enjoying themselves at the smorgasbord held during the North Eastern District Meeting. Above, right: (*left to right*) Mrs. Ben Sullivan, AIEE President M. D. Hooven, Glen Lyon, and N. S. Hibshman, secretary AIEE, relaxing after the smorgasbord.



AT THE GENERAL SESSION during the North Eastern District Meeting, a group (above) listen to AIEE President M. D. Hooven (*right*), and A. M. Beebee (*left*), president, Rochester Gas and Electric Company, who gave the main address of the session, "Public vs Private Power—Which Is Right?"

a Public Service Commission on a strict "cost of service" basis, there is no profit as the word "profit" ordinarily is understood. Under these conditions, the people benefited pay only the cost of the benefit, but they carry their fair share of tax burdens, too.

Proponents of public power have claimed that the waters belong to all the people in the state. If that is true, it is therefore important that all the people of the state benefit rather than just a certain few. The only way that the general public can equitably get the benefit, however, particularly in areas distant from the development, is to have this program carry its fair share of taxes in addition to paying rentals for the use of the water. In this way, all the people of the state benefit through a reduction in their taxes, everybody is treated in the same manner, nobody rides on the backs of others, no special privilege is given to certain groups, and the customer gets his electricity at the lowest real cost when all costs are considered.

Technical Sessions

There were 11 technical sessions at which 41 papers were given. The subject matter dealt mainly with power apparatus, but several sessions were devoted to wire and radio communications and electronic devices so that a well-rounded program was presented to the members.

In the session on instrumentation, the opening paper, "Modern Pneumatic-Servo Systems," by G. F. Akins, Eastman Kodak Company, was a demonstration of fundamental testing and processing devices in which air or some other gas was combined with electricity. In some cases, the end result was the measurement of the gas pressure or temperature, and in others, the pressure or temperature was to control some type of manufacturing process. In the discussion following the paper, a great deal of interest was shown in the over-all efficiency of the systems demonstrated. Mr. Akins stated that the accuracy should be within 1 per cent of the span of readings.

R. N. Brey, Leeds and Northrup Company, explained the basic systems of instrumentation connected with nuclear reactors. The changes affecting the radioactivity of the core are most critical and must be given immediate attention if any instrumentation or control processes get out of order.

In the wireless communication session, the first paper was a discussion on some of the critical areas of design of electronic equipment which affected the performance of that equipment or others in the vicinity. A. L. Albin and H. M. Sachs, Armour Research Foundation, stated in their paper that too little attention was paid generally to the construction of metallic containers which housed high-frequency electronic apparatus and that serious interference resulted. The paper described remedial measures which can be taken to reduce this interference to a minimum.

The next paper was a description of a squelch circuit by L. M. Harris and J. Evans, Stromberg-Carlson Company. This circuit was developed for a short-range f-m receiver used by the U. S. Army and consists of a 10-kc oscillator working into a second local oscillator with frequency modulation (the receiving circuit is a double superheterodyne) and also into a synchronous detector fed from a 10-kc tuned amplifier and working into a relay amplifier and relay. This has been named the locally generated keying-tone squelch circuit. Although there are two or three additional tubes required in the circuit, they are operating at audio frequencies and can be replaced by transistors with an attendant increased reliability and life.

Mark Jordan, General Electric Company, presented "Wire Line Termination for Microwave Relay Systems." This was a description of the building-block system used in termination assemblies which makes them versatile and easily replaceable. There are 26 "blocks" or matrixes which can be used for changes or expansions of any type of system. In a session devoted to wire communication, I. S. Coggeshall, Western Union Company, presented "From Telegraphic Dot to Binary Bit." This was an appropriate start to the session as it was a century ago that Ezra Cornell and Hiram Sibley started the Western Union Telegraph Company in Rochester, N. Y. It was also appropriate to present this paper at the meeting as Norvin Green, the first president of AIEE, was the fifth president of the telegraph company.

Comparing the rapid spread of the frontiers of America to the slow growth of European boundaries, Dr. Coggeshall attributed America's growth to the telegraph and the railroad. In fact, the telegraph was the forerunner of of the later forms of electrical communication.

While the Morse code of dots and dashes remains virtually unchanged, its transmission and reception has undergone several changes in an effort to decrease the time consumed for a message to be sent. With this increase in speed has appeared automatic error checking.

The speaker also demonstrated how the elimination of vowels in telegraphic messages, as used in Associated Press transmissions, did not detract from the intelligence sent and how there was a natural evolution from these speeded-up codes to the transmission of binary bits. Furthermore, that such bit transmission had evolved into nonlanguage control transmission, is exemplified in office machines, automation, etc.

Another interesting paper in this session was one describing the Syncroscan, by H. C. Sibley, General Railway Signal Company. This signalling system operates over one pair of line wires and is divided into two functions: controlling and indicating. The former uses direct current or one carrier-current channel and the indication system uses two carrier-current channels, one for synchronization and one for indication. Voice-frequency telephone and other carriers may be operated over the same pair of wires and these channels are generally operated below 20 kc to keep line attenuation low. Minimizing this permits operation over longer distances with more field locations before repeaters are needed.

The Syncroscan system is a new approach to centralized traffic control and uses an electronic scanning system to provide speed and capacity necessary to report instant information over hundreds of miles of railroad.

One of the most enthusiastic sessions was the one devoted to ethics in engineering, at which P. T. Elliott presided. The great interest shown was due in the main to the use of an electrical opinion meter, shown in the accompanying illustrations. By means of individual controls connected to this meter, members of the audience could register their votes secretly and the group's opinion or vote was indicated by the meter's hand. There was no hesitancy in expressing an opinion on some of the very controversial questions which were posed by the panel because of this freedom, and the session was very enjoyable.

The panel consisted of Col. C. H. Brown, retired consulting engineer of Rochester; D. E. Garr, General Electric Company; and Prof. H. W. Bibber, Union College, Schenectady, N. Y.

Col. Brown stated that the obligation of a professional engineer is the highest in everything he does and that by definition, a profession is "a calling in which one professes to have special knowledge for use in the service of others." After short talks by the other members of the panel, the meeting was thrown open for discussion and following are some of the questions asked, voted upon, and the results.

Q. Do you think your company is paying for your trip to this meeting so that you will represent them? Vote: 25 per cent yes.

Q. Has your attitude toward ethics changed since you have been put in a supervisory position? No.

In connection with receiving presents and hospitality from a client or a supplier:

Q. Do you think you have character enough

MEETING HIGHLIGHTS

North Eastern District Meeting

AT THE NORTH EASTERN District Meeting held in Rochester, N. Y., May 2–4, G. F. Akins (above), Eastman Kodak Company, demonstrates pneumatic-servo control systems during the session on Instrumentation. Mr. Akins opened the session with a paper that was entitled "Modern Pneumatic-Servo Systems." Left: At Papers and Inspection Trips desk (*left to right*) AIEE President M.D. Hooven; AIEE Vice-President G. J. Crowdes; and C. G. Plomasen, Eastman Kodak Company, general chairman, discuss one of the papers. Left, top: At station WHAM in Radio City (*left to right*) Mr. Plomasen, President Hooven, and Anne Rogers, who interviewed them on her radio program.

Photographed by Fred Bergmeyer, Rochester Gas and Electric Company

IN CONVERSATION between sessions, above, left: (*left to right*) A. M. Beebee, Rochester Gas and Electric Company; I. S. Coggeshall, Western Union Company; and E. M. Morecock, Rochester Institute of Technology. Above, right:

(*left to right*) S. Sabo, Japanese Institute of Electrical Engineering; H. W. Bibber, Union College; and G. J. Crowdes, Simplex Wire and Cable Company, AIEE vice-president.

Above, left: The electrical vote registering meter which was used to register audience opinion during the session on Ethics in Engineering. Behind the table are (*left to right*) C. H. Brown, retired consultant; H. W. Bibber, professor of electrical engineering, Union College; P. T. Elliott, presiding; and D. E. Garr, General Electric Company. Above, right: The audience during the same session, showing individual voting controls connected to the vote meter.

not to be swayed by presents? 70 per cent yes.

Q. Do you think this matter of presents from an ethical standpoint is important? 70 per cent yes.

Q. Do you think it ethical for a college to accept a certain amount of money per student from a company if that graduate remains with the company for at least a year? 79 per cent yes.

Q. Is it ethical for a company to put a student on half salary from the time he signs up with that company until he graduates? 50–50.

Q. If all companies did this, do you think it ethical? 70 per cent no.

Q. Is it ethical for an employee to take an evening job with another firm making a competing product without telling his employer about it? No.

Q. Same as one above, if the employer does not make a competing product? Yes. To do consulting work? 70 per cent yes.

Q. Is it ethical for an employed man to work on an invention at home, whose employer makes a similar product? 50-50.

Q. Do you feel that the practices of ethics are improving on the part of individuals? 60 per cent yes. On the part of industry? 70 per cent yes. On the part of engineers? 70 per cent yes.

Q. Has this discussion been a complete flop? 80 per cent no.

President Hooven's Address

At the dinner-dance on Thursday evening, AIEE President Hooven told the gathering that the electrical engineer, whether he wishes to or not, belongs to an intellectual aristocracy, keeps out of jail, makes a good husband, and eventually gets his just reward in the way of better office surroundings, excellent salary, beautiful secretaries, etc.

In the days of ancient Egypt, engineers belonged to the palace nobility and now they are being invited into the circle of intellectuals as "diligent missionaries are exhorting the top 25 per cent of high-school students who go to college to take up engineering as a profession."

Studies have shown that 68 per cent of the engineering students pass the Student Deferment in Selective Service, compared with the national average of 53 per cent. Moreover, the annual demand for new engineers today is greater than the demand for new practitioners in the law, ministry, and medicine combined.

That engineers make good husbands is evidenced by the fact that they have a very low divorce rate: less than 2 per cent compared with the national average of 25 per cent. Considering the long hours he has to work, his proverbial absent-mindedness when lost in a fog of speculation, and his well-known tendency to fix his neighbor's radio receiver while his own goes unmended, it speaks well for the engineer's personality and amiability that he stays married to the same girl. Perhaps his willingness to stay at home keeps him out of trouble.

In the technological world, the engineer must work without the spur of public concern and interest which usually goes along with medical research, because the engineer's problems must be solved before they occur, even before many people think about them. In other words, engineers must wish to achieve for achievement's sake.

Student Paper Competition

On Friday morning, the District student branch prize paper competition was conducted with five colleges represented. The winning paper, "Development of the Klystron Tube," was given by R. E. Jacobson, University of Massachusetts, and the second prize was warded to H. A. Spang III, Yale University, for his paper, "Pulse Response of Gas Diodes."

The judges for the competition were E. C. Karker, Rochester Institute of Technology; L. C. Holmes and Don Wilson, both of Stromberg Carlson Company; and Fred Baker. C. E. Tuites, Rochester Institute of Technology, was chairman of the student prize paper contest.

Committees

The members of the North Eastern District Committee were: C. G. Plomasen, general chairman; J. A. Gienger, vice-chairman and secretary; J. D. Hershey, Advisory; H. A. Brown, chairman Rochester Section; E. M. Morecock, Meetings and Papers; R. H. Rankin, Registration and Hotel Reservations; C. E. Tuites, Student Meeting; R. A. Whitford, Finance; Mrs. R. A. Whitford, Women's Arrangements; Francis Drake, Publicity; G. F. Gleason, Inspection Trips and Transportation; J. T. Johnson, Treasurer and Budget; R. W. McCarty, Dinner Dance; J. A. Scott, Smorgasbord and ABC Bowling Party; Frank Starr, Meeting Room Arrangements.

Electronic Components Symposium Held May 1–3

A HIGHLY SUCCESSFUL symposium on electronic components was held in Washington, D. C., May 1–3. Symposium headquarters was at the Roger Smith Hotel with technical sessions presented at the Department of the Interior Auditorium. Sponsors included the AIEE, Institute of Radio Engineers, Radio-Electronic-Television Manufacturers Association, and West Coast Electronic Manufacturers Association, with participation by the agencies of the Department of Defense and the National Bureau of Standards.

The general session featured a welcoming address by A. W. Rogers, chairman of the Symposium Committee. An interesting paper by G. W. Dummer of the Radar Research Establishment, Malvern, England, and presented by C. E. Richards, outlined some of the recent British developments in electronic components.

At the six technical sessions held throughout the 3-day symposium, 36 papers were presented covering progress with materials, theory and operating principles, instrumentation and measurements, electron tubes

and solid-state devices, and passive components.

Albert Zack of Sylvania Electric Products, Inc., presented a paper by Trevor Temple on the subject of back swing in high-power pulse transformers. Unidirectional damping by means of a diode across the tertiary winding was one of the recommended methods for controlling back swing.

Another interesting paper was "The Use of Dispersion Measurements for Analyzing Ceramic Components" by D. A. Lupfer of the General Electric Company. It was shown that dispersion and absorption data may be used to give important materials information on polycrystalline ceramics.

In a paper by H. W. Hermance and T. F. Egan of Bell Telephone Laboratories, a new technique for determining contact contamination was described. The process consists of pressing the contact into a piece of warm thermoplastic. The impurities are lifted onto the plastic, providing an optically clear base which permits microscopic examination. The surface texture is reproduced in reverse relief on the plastic replica.

The important subject of nuclear radiation effects on electronic components was discussed in a paper by C. C. Robinson of Wright Air Development Center. He outlined some of the results to date of tests being conducted on semiconductors, various insulation materials, etc.

In his paper, "Quality Control of Magnetic Subassemblies," Norton Cushman of Sprague Electric Company described the testing of magnetic cores for digital computers under pulse conditions. Important characteristics include rise time, fall time, peak amplitude, and undershoot.

Two papers on metal film resistors were presented by engineers from the International Resistance Company. "Metal Film Power Resistors," by J. J. Bohrer, W. E. Hauth, Jr., and S. J. Stein described the specification requirements and advantages of these resistors. A paper by S. J. Stein and J. Riseman, covering precision and high-temperature metal film resistors, described their ability to operate with high stability at ambient temperatures of 250 C.

A new type resistor was described in a paper by R. C. Langford and J. Ruckelshaus of Weston Electrical Instrument Corporation. Manufactured under the trade name of "Vamistor," these are thermally fused metal-to-ceramic volume resistors. Features include exceptionally high strength and ruggedness.

Proceedings of the symposium will be published and may be obtained from Engineering Publishers, GPO Box 1151, New York 1, N. Y. at $5 per copy, postpaid.

1955 National Electronics Conference Proceedings Available

Proceedings of the 1955 National Electronics Conference (NEC) now can be obtained at $5 per copy from the NEC headquarters, 84 E. Randolph St., Chicago 1, Ill.

The 1,040-page, cloth-bound book contains the 102 technical papers and three luncheon addresses presented at the 11th annual meeting held in Chicago, Ill., October 1955.

In addition to the 1955 volume, the following back issues of the NEC Proceedings are available: 1946, 1949, 1950, 1951, 1952, 1953, and 1954.

Advance orders also are being taken for Proceedings of the 12th annual National Electronics Conference, to be held October 1–3 at the Hotel Sherman in Chicago.

More than 10,000 persons are expected to attend the 1956 Conference, which is the nation's leading forum on electronic research, development, and application.

The conference is sponsored by the AIEE, Institute of Radio Engineers, Illinois Institute of Technology, University of Illinois, and Northwestern University.

Also participating in the conference are Michigan State, Purdue, Michigan, and Wisconsin Universities, as well as the Radio-Electronics-Television Manufacturers Association and Society of Motion Picture and Television Engineers.

New AIEE Technical Division Approved by Board of Directors

Because of the increased importance of instrumentation in electrical engineering, a sixth major technical division of the AIEE, to be known as the Instrumentation Division, has been approved by the Board of Directors, N. S. Hibshman, Institute secretary, has announced.

The new division, of which C. F. Savage, Jr., General Electric Company, New York, N. Y., has been named chairman, will begin operations as a division August 1. At present, it is part of the Science and Electronics Division, and is known as the Committee on Instruments and Measurements.

Present subcommittees on indicating and integrating instruments, recording and controlling instruments, electronic and high frequency instruments, special instruments and auxiliary apparatus, telemetering, nucleonic and radiation instruments, and navigation instruments, will become committees under the new setup.

Other Technical Divisions of the Institute are those on Communications, General Applications, Industry, Power, and Science and Electronics.

Engineering Foundation Grants Go to 27 Projects

A wide range of engineering research will be advanced with new grants appropriated by Engineering Foundation at its annual meeting held in New York on May 3. Allocations for the 1956–57 fiscal year total $53,000. They will go to 27 projects, which are receiving estimated outside support of $497,500. The projects are being carried out mainly in university, Government, and industrial laboratories all over the country under sponsorship of the major engineering societies.

Projects receiving funds represent all the major branches of the profession, and range from a program for predicting disastrous storm surges, which got under way last year under sponsorship of the American Institute of Mining and Metallurgical Engineers, to a recently instituted three-year research project on the Thermal Resistivity of Soils, which is being co-sponsored by the AIEE, Engineering Foundation, and other groups.

A project started last fall to attack the problem of metallic corrosion, which annually costs industry enormous sums in replacement costs, is also receiving a grant. The newly created Corrosion Research Council of the Engineering Foundation, a project of the American Institute of Mining and Metallurgical Engineers, the Intersociety Corrosion Committee, and the Electrochemical Society, will make an all-out effort to help industry in the solution of its primary problem. It will do this by pro-

Arkansas Section Officers

Courtesy Shrader

The incoming officers for the Arkansas Section of the AIEE are: (*left to right*) M. M. Riggs, secretary; H. J. Owen, vice-chairman; R. H. Boyd, chairman; K. C. Johnson, F. J. Wilson, and R. W. Newby, Jr., directors. Another director, D. N. Kobernuss was not present at the May 18 Meeting at which the election results were announced. The new officers assumed their positions at the June 16 Meeting.

viding more basic scientific data and by encouraging closer co-operation of the interested groups.

In its initial stages, the project will include a study of the reactions that take place on the surface of a metal single crystal in pure water containing various amounts of oxygen. Major attention will be paid to the film of adsorbed layers that forms on the metal when it comes in contact with water, and to the role that the film plays in controlling the passage of the metal cations into solution. Copper will be the first metal studied because of its structural simplicity and the ease of preparing single crystals. Later when techniques have been developed, the same method will be used to investigate the more complex metals, particularly iron and its alloys. The work will be conducted at the National Bureau of Standards under the general direction of an advisory committee headed by Dr. A. T. Gwathmey, of the University of Virginia.

Similarly important to industry is another project receiving one of the grants—a study of the Properties of Steam, which is being sponsored by the American Society of Mechanical Engineers (ASME). The Steam Properties Research Program, which was set up at the Fourth International Steam Tables Conference in Philadelphia, Pa. in September 1954, revives an earlier ASME program that was completed in 1934. Taking into account the extremely high pressures and temperatures in use today in both steam power generation and chemical processing, the reinstituted program has the ultimate aim of revising and extending the whole field of knowledge of steam properties, including its transport properties. As a first step, it is trying to obtain experimental data for extending the steam table range to 1,500 F and 15,000 psia. The present working steam tables have been in use since 1934.

The steam studies are under way in a number of colleges and at the National Bureau of Standards, where important work is being done in the establishment of new temperature standards and a set of conversion factors between the international temperature scale and the true thermodynamic scale. The entire program is functioning within an international framework.

Engineering Foundation, which was founded in 1914, administers the income from a $1.5 million fund dedicated to the stimulation of engineering research. This annual income of some $50,000 has had an importance out of all proportion to its relatively modest size. It has been judiciously used over the years to aid in the early stages of many research programs that later were able to obtain large-scale financial backing and which developed into important projects.

Plans Announced for AIEE Petroleum Conference

The third AIEE Electrical Conference of the Petroleum Industry will be held in Kansas City, Mo., September 17–19, 1956. Headquarters will be the Muehlebach Hotel. Arrangements have been made for an exhibition hall where electrical equipment used in the petroleum industry will be displayed. Those interested in obtaining space for exhibits should contact Fred S. Jones, Platte Pipe Line Company, 1200 Power and Light Building, Kansas City 5, Mo.

AIEE To Commemorate Tesla Centennial in Fall

This year, the AIEE, at the Fall General Meeting, will be among the American scientific and engineering societies who will honor the centennial of the birth of Nikola Tesla.

Mr. Tesla, who was born July 10, 1856, is most prominent for the polyphase system of a-c power transmission which he presented in 1888. This system, which has since become universal, embraces the entire field of constant-speed synchronous, induction, and split-phase motors.

His many contributions to science and industry are indicative of his outstanding inventive powers. During the years 1891–93, he made the first public announcement of researches on the phenomena of alternating current of high frequency and potential. Out of his famous "trio-series" of lectures, delivered in the United States and Europe during this time, came many pioneering discoveries and inventions, among which were the construction of neon signs and display of cold-light, fluorescent lamps; the first announcement of a system of radio transmission comprising the essential tuned coupled circuit and aerial-ground connection elements; introduction of the "Tesla Coil"; and the phenomena and method of high frequency induction heating. Between 1894 and 1897, Mr. Tesla made discoveries in

DR. NIKOLA TESLA perusing a volume of the "Scientific Papers" of Maxwell. One of his high-voltage research coils is in background. The 100th anniversary of his birth will be commemorated at the AIEE Fall General Meeting, October 1–5, Morrison Hotel, Chicago, Ill.

radiations, material streams, and emanations, contributing to the fundamental understanding of X-ray and atomic radiations. In 1898, he developed and patented a system of radio control of remote objects. While conducting secret research at Colorado Springs, Colo., in 1899, he produced the most powerful electrical discharges ever achieved by man, surpassing natural lighting. During the years 1900 to 1905, he erected his famed Long Island, N. Y. Research

Fall General Meeting Committee

Commonwealth Edison Photo

LAYING THE GROUNDWORK for the AIEE Fall General Meeting to be held in Chicago, Ill., October 1–5 at the Hotel Morrison, are the officers and committee chairmen: (*from left, around the table*) E. F. Koncel, Commonwealth Edison Company, secretary; B. T. Carmody, S and C Electric Company, hotel arrangements; Mrs. F. A. Larson, ladies activities; F. M. Scott, Allis-Chalmers Manufacturing Company, treasurer; F. A. Larson, General Electric Company, entertainment; C. F. Hill, Vern Alden and Company, technical program and monitors; W. M. Ballenger, General Electric Company, general chairman; M. J. Adams, I-T-E Circuit Breaker Company, special activities; D. H. Beal, Illinois Bell Telephone Company, Fall Frolics; D. L. Levine, Commonwealth Edison Company, registration; H. E. Nason, Westinghouse Electric Corporation, trips and transportation; H. H. Finch, Sargent and Lundy, finance and budget; G. L. Welch, Westinghouse Electric Corporation, vice-chairman; and J. T. Tyner, *Electric Light and Power*, publicity. The Fall General Meeting will commemorate the 100th anniversary of Nikola Tesla, inventor of the present-day polyphase a-c system of power transmission.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until July 27. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before July 27.

56-88 **Design of the Resistively Loaded Static Frequency Doubler.** *P. P. Biringer*

56-214 **Wind Tunnel Investigation of Conductor Vibration Using Rigid Models.** *F. B. Farquharson, R. E. McHugh, Jr.*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

Laboratory at Wardenclyffe for the purpose of experimenting with wireless power transmission. His next project included research and patents on a mechanical principle, embodied in a variety of machines as reversible gas and steam turbines, mechanical transformers, and pumps. He also received patents on helicopters, speed indicators, frequency and flow meters, and lightning protectors. Mr. Tesla's last research studies, before his death on January 7, 1943, at the age of 86, were in telegeodynamics and an ultra-high voltage d-c power transmission system.

AIEE Luncheon Honors President and Secretary of IEE

Sir George Nelson, president of The Institution of Electrical Engineers (IEE), and W. K. Brasher, secretary, were the guests of honor at a luncheon given by the AIEE at the Engineers' Club, May 21. Twenty-five prominent engineers including the presidents and the secretaries of other societies and R. H. Barclay, honorary secretary of the IEE, attended the luncheon. Sir George and Mr. Brasher stopped off to visit Institute headquarters and conduct business while enroute to an annual meeting of the Engineering Institute of Canada. Following the luncheon they attended a meeting of the secretaries of the several societies.

AIEE President Hooven extended a cordial welcome to the very distinguished guests and the distinguished gathering. In relation to the short supply of engineers, President Hooven referred to an inscription on a plaque recently presented to the Engineering College in Bedford, England, which reads: "to ensure the boys passing thru Bedford School be continually reminded of the absolute dependence of Britain on engineering as a profession." What is true there is true here and the words, "the whole world" could be substituted for "Britain" in the inscription.

In addressing the gathering, Sir George explained that Great Britain had to produce things to obtain money to buy food on which to live. He continued to say that he did not come here to take bread from the door of any American, but he deplored the cut-throat methods of competition for technical manpower. In Great Britain, the institutions were pressing government to expand and improve training facilities but this was a long-term project and the immediate problem was to avoid wasting engineering personnel. He stated that there are three main tasks to the problem: (1) increase quantity and quality of output of engineers, (2) make the most efficient use of available technical manpower, and (3) maintain a proper balance between research, development, and production.

Sir George suggested a limitation on excessive competition and commended as an example the British Central Electricity Authority going to four groups of manufacturers for atomic power stations. This combines the advantages of keen competition without waste of establishing too many small inefficient teams.

While here in the capacity of president of the IEE, Sir George Nelson has rendered considerable service to his government. He is Chairman of the Board and Managing Director of English Electric Company, Ltd.

AT THE LUNCHEON honoring IEE officers were: (*left to right*) W. K. Brasher, secretary of IEE; Sir George Nelson, president IEE; M. D. Hooven, president AIEE; and R. H. Barclay, local honorary secretary.

Conference on Instrumentation Held in Boston

On April 26 and 27, the Group Subcommittee III, Recording and Controlling Instruments, of the Committee on Instruments and Measurements, sponsored a National Technical Conference at the Hotel Bradford, Boston, Mass. The theme of the conference was "New Developments in Instrumentation for Industrial Control." This conference featured information display and recording, automatic data handling systems, advanced instrumentation systems in industry, and computer-controlled systems for industry. Outstanding speakers were on hand to discuss the scope of this conference. Approximately 400 people attended the meeting, at which 19 papers were presented. A conference proceedings or report will be published containing these papers and will be available in the near future.

AIEE New York Section Elects Officers

W. A. Clark, an engineering executive with the American Telephone and Telegraph Company (AT and T), has been elected 1956–57 chairman of the New York Section of the AIEE, according to an announcement by R. T. Weil, present chairman.

Others elected were R. W. Gillette, Consolidated Edison Company, vice-chairman; W. T. Rea, Bell Telephone Laboratories, secretary; E. K. Murphy, Rayonier, Inc., treasurer; William Vieth, Western Union Telegraph Company; and B. B. Jordan, Western Electric Company, Inc., members at large.

Terms of office will be August 1, 1956, to July 31, 1957.

Mr. Clark is a 1921 graduate of Purdue University and since then has been associated with Headquarters Staff of AT and T. He has been active in the Section and in AIEE national affairs for many years.

The New York Section is the largest of 109 AIEE Sections, and has a membership

of more than 7,000 in metropolitan New York, Long Island, northern New Jersey, and the Hudson Valley.

Portland Section Holds Management Symposium

The AIEE has long encouraged its engineers to train and fit themselves for future management positions. More and more engineers find themselves suddenly appointed to executive status without the benefit of anything other than an engineering background.

The Portland Section of the AIEE has taken a great step forward in the direction of broadening the engineer's knowledge of management by sponsoring a series of evening lectures and discussions for its members. Recently concluded was a series of nine two-hour programs presented by top-level management people and educators selected from the Portland area. The speakers concentrated on the general objectives of management such as organization, personnel, planning, and administration. A similar course last year was devoted to functional operations of management such as marketing, sales, and finance.

The intention of these programs was to provide those attending the course with some of the tools of executive ability which may be applied anywhere regardless of existing or future position.

NSPE Adopts Employment Practices Criteria

A check-list criteria of employment practices for the guidance of professional engineers and their employers has been adopted by the Board of Directors of the National Society of Professional Engineers (NSPE).

The criteria were presented to the Board as a recommendation of the Society's Engineer-in-Industry Committee at the group's annual meeting in Atlantic City, N. J., May 24–26.

Printed in check-list format, the criteria cover specific categories of engineering career development, starting with the recruitment of the engineer and leading through the various phases of his experience. The questions on the check-list suggest the responsibilities of the employer to his professional employees, and the latter's responsibilities to the employer.

Topics included in the criteria are recruitment, indoctrination, technical administrative, personality, and professional development of the individual, salaries, engineering titles, personnel practices, and termination policies.

In another principal action at the Atlantic City meeting, the NSPE Board took under consideration an Ideal Registration Law for professional engineers. Major engineering societies will be invited to review the ideal law.

R. J. Rhinehart (M '50), newly elected president of NSPE, stated that the ideal law is designed to be "a much needed step in the direction of achieving uniform standards of professionalism for registered engineers on a nation-wide basis."

A CLASS IN SESSION at Reed College, Portland, Ore., during the Management Development Symposium sponsored by the Portland, Ore., Section of the AIEE. Moderator Howard Arnett, executive assistant to the Chairman of the Board, Portland General Electric Company, is seated at the right.

The Board also adopted an amendment of the NSPE bylaws to provide for the creation of functional sections on a national level.

The functional sections, to be established by the Board, will be made up of NSPE members having common professional problems and interests. The bylaw amendment states that the functional sections "shall be so conducted as to provide effective forums for discussion and united action on the part of members grouped according to type of professional employment, for the enhancement and betterment of professional recognition and status, and other matters of mutual welfare."

In the final banquet session of the NSPE meeting, Air Force Secretary D. A. Quarles (F '41), past-president of the AIEE, 1952–53, received the group's Annual Award for meritorious service to the engineering profession.

He was presented with an engraved plaque citing him for his "outstanding contributions as a professional engineer to the national defense, the advancement of public welfare through research and development, and for industry and service to the highest principles of the engineering profession."

Proceedings of EJC General Assembly Available

The Proceedings of the Engineers Joint Council (EJC) Second General Assembly, held January 26–27, 1956, in the Hotel Statler, New York, N. Y., have recently been published.

A complete account and coverage of the panels held and the addresses presented on both days are included. Thursday's program began with a panel on the Reserve Forces Act of 1955, presided over by H. A. Meyerhoff, executive director of the EJC

Courtesy Central Studios

AIR FORCE SECRETARY D. A. Quarles (*right*) receives the Annual Award of the National Society of Professional Engineers from A. C. Neff, National Society president, at the group's annual meeting in Atlantic City, N. J.

Scientific Manpower Commission. This was followed by the luncheon speech, "Brainpower—Our Greatest Asset," delivered by F. H. Bowles, director, College Entrance Examination Board, New York, N. Y. The session held Thursday afternoon consisted of an extensive panel on Extending Engineering Manpower by Utilizing Balanced Teams of Engineers and Engineering Technicians. The presiding officer was M. M. Boring, chairman, EJC Engineering Manpower Commission. The program presented on Friday began with a panel on the Growth Pattern of the Engineer, moderated by S. D. Kirkpatrick, vice-president, McGraw-Hill Book Company, Inc., New York, N. Y. The luncheon address which followed, "Some Major Findings of the Hoover Commission," was given by S. C. Hollister, dean, School of Engineering, Cornell University, Ithaca, N. Y. This served as an introduction to the panel held Friday afternoon, "The Hoover Commission Reports—A Review of the Engineering Aspects." The concluding event of the General Assembly was a dinner speech, "A World Look at Usefulness of Nuclear Power," presented Friday evening by W. L. Cisler, president, Detroit Edison Company, Detroit, Mich.

The Proceedings may be obtained for $1 per copy from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

Chicago Section Announces Papers Competition Winners

Awards in the 1956 Chicago, Ill. Section Papers Competition were presented during a well-attended section general meeting on May 3 at the Western Society of Engineers building. The judges selected three papers out of the five entries for awards. First prize was won by G. T. Flesher for his paper, "Radiation, Conservation, and Circuit Paradoxes." Alan Plait and Harold Gruen received second prize for "The Effects on the Frequency of VHF Crystal Oscillators Resulting from the Use of a Compensating Inductance." Third prize was awarded to H. M. Sachs and A. L. Albin for their paper, "Control of Radio Interference from Medical Electronic Equipment." At the final presentation, each author or coauthor was allowed 10 minutes to present an oral resume complete with charts or graphs.

CHICAGO SECTION Papers Contest prize winners (*left to right*) G. T. Flesher, department of electrical engineering, Illinois Institute of Technology; Alan Plait and Harold Gruen, both of Armour Research Foundation; and H. M. Sachs, Armour Research Foundation, who accepted third prize for a paper which was coauthored by A. L. Albin, who was unable to attend.

E. R. WHITEHEAD (*left*), chairman of electrical engineering department, Illinois Institute of Technology, takes over chairmanship of the Chicago Section from Robert Gear, purchasing agent, Commonwealth Edison Company.

Engineer Prominent in National Recognition Award

R. L. Jacobsen (AM '50), electrical superintendent of the Montana Dakota Utilities, Dickinson, N. D., headed one of the Dickinson Chamber of Commerce Committees as it culminated 50 years of activity with the winning of a National Recognition Award at the 44th annual meeting of the United States Chamber of Commerce in Washington, D. C., on April 30, 1956.

The National Recognition Award was presented to the Dickinson Chamber of Commerce by Boyd Campbell, president of the United States Chamber of Commerce, for its outstanding achievement and evidence of conduct of an effective program of work in four fields of activity: business development, community betterment, good citizenship, and organizational improvement.

Additional Conference Papers Now Available

The following is the list of conference papers presented at the 1956 South West District Meeting and Great Lakes District Meeting which were not numbered at the time of the meetings. They have now been numbered and are available to members for 40¢, and to nonmembers for 80¢. Send order and remittance to: AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

South West District Meeting, April 2–4, 1956, Dallas, Tex.

DP56-485 Lightning Protection of H-frame Transmission Lines Using One Expulsion Protector Tube per Structure. *J. F. Longley*
479 A Unique Design for 230-kv Wood Pole Transmission Line. *C. W. Gragg, H. N. Wright*
494 Use of Synthetic Resin in Splicing and Terminating Power Cables. *W. A. Parker*
DP56-495 A Planned Electrical Expansion. *E. G. Parrish, J. R. Straby*
497 Transistor Aircraft Interphone Amplifier Systems. *G. S. Rambo, Jr.*
478 Electrical Engineering Role in Nucleonics. *W. J. Graff*
482 Nuclear Power Plant Development. *R. W. Klecker*
509 Trend and Development in Large Turbine Generators. *J. A. Zimmerman*
471 Load Characteristics and their Effects on Distribution System Design. *H. E. Campbell*
483 Fuse Protection of High Voltage Transformers. *Roy Larner*
486 Electronic Power Supplies in Aircraft. *H. T. Lescell*
499 Problems of the Utilities Furnishing Power to Chemical Plants. *M. T. Robbin*
489 Chemical Plants Considerations in the Use of Purchased Power. *W. S. Miller, J. H. Valcik*
480 Expansion of Electrical Facilities in Chemical Plants. *H. N. Hiebak*
487 Over-all Aspects of Motor Control in Chemical Plants. *H. E. McConnell*
496 Electronic Equipment Design Considerations Relative to Vibration and Shock. *B. L. Powell*
508 Design of Electronic Equipment to Resist Shock and Vibration. *K. C. York*
491 High Voltage D-C Testing of Cables and Cable Fault Locations. *B. J. Naukarois*
470 Corona in Metal-Clad Switchgear. *H. O. Borgne*
500 Problems and Limitations of Electrical Installations in Class I, Groups A and B, Hazardous Locations. *Dick Scott*
506 Motor Insulation Developments in the Chemical Industry—Now and Tomorrow. *J. T. Wilson*
492 Insulation Coordination as Affected by New Arrester Characteristics. *A. M. Opsahl*
472 An Evaluation of Lightweight Storage Batteries. *Ward Carter*
490 Integration of D-C Power Supplies for Airborne Electronic Equipment. *J. M. Murphy, H. D. Stanner*
484 Simplify Utility Radio Communications. *F. V. Long.*

Great Lakes District Meeting, April 16–18, 1956, Fort Wayne, Ind.

DP56-531 Modern Test Procedures and Equipment for Magnet Wire. *Richard Dermer, John Whitney, Thomas Cofin*
563 Inorganic Pigment Method for Stack Loss Determination. *F. A. Sattler, F. F. Trunzo*
536 Combination Dacron and Glass for Magnet Wire. *R. W. Hall, R. N. McKnight*
577 Magnet Wire Varnish Compatibility. *W. W. Wareham*
556 Industry Views the Electrical Engineering Curriculum. *G. E. Moore*
540 Twice as Much for Your Engineering Manpower Dollar, *A. R. Hollworth*
573 Who Should Be Admitted to the Engineering Colleges. *A. H. Spalding*
567 The Westinghouse Nuclear Testing Reactor. *M. A. Schultz*
565 Engineering the Future Power Transformer. *L. W. Schoenig*
538 Engineering Features of the Super-Fluorescent Street Lighting Installation in Indianapolis. *J. H. Hordy, J. H. Swals*
544 New Uses of Ceramics in the Electronic Tube Industry. *H. Huffcut*
552 Glass in Electronics, *W. H. McKnight*
533 Basic Concepts. *P. T. Farnsworth*
527 Load Characteristics and Their Effect on Distribution System Design. *H. E. Campbell*
541 12 Kv—And Then What? *H. L. Hess*
526 Transistor Operational Amplifier. *G. B. Bush*
553 Transistorized Linear Sweep Generators and Precision Amplitude Comparator. *L. C. Merrill*
572 A Transistorized Strain Gauge Amplifier. *J. H. Smith*
561 High Frequency Transistor Amplifier. *W. D. Penn*
539 Temperature Distribution in Electrical Coils. *H. B. Harms*
576 Application of Digital Computer to Design of Small Transformers. *Glenn Walters*
569 Static Switching of Control Circuits. *J. Sheets, W. Alvarez*
547 Winding with Controlled Tension. *H. L. Kelley*
554 Measurement of Torque Pulsations During Start of Alternating Current Motors. *M. L. Miller, F. H. Wright*

DP56-557 Thermal Aging Studies on Insulation Systems for Electrical Machines. *G. L. Moses*

570 Infrared Studies of Thermal Aging on Organic High Temperature Films. *A. L. Smith, J. F. Dexter*

571 Epoxide Resin Coatings for Magnet Wire. *E. L. Smith*

560 Compatibility Tests of Enameled Wires in Closed Systems. *W. W. Pendelton, E. H. Olson, H. L. Saums*

535 D-C Field Coil Testing. *T. J. Gair, C. W. Wallace, Jr.*

523 Special Test Equipment. *Donald Ackworth*

529 Iatron Storage Tube Characteristics. *Dean Davis*

532 New NEMA Frames for Polyphase Induction Motors. *R. J. Dineen*

548 New NEMA Industrial D-C Motor. *A. W. Kimball*

558 Thermal Protection and Control. *E. P. Jastram, Jr.*

568 A Comparison of 69-Kv Transmission Line Construction. *Walter Schulz*

546 History and Development of the Post Insulator. *Ralph Jenner*

580 AIEE Test Code for Specialty Transformers. *A. V. Hughes*

DP56-537 Dip Coating for Small Dry-Type Transformers. *R. L. Hamilton*

564 The Design of Motors for Submersible Operation in Deep Wells. *E. J. Schaefer*

579 A Design Engineer's View of Shaded Pole Motor Applications. *J. C. Willsey*

559 Design Factors and Problems of Motors for Electric Appliances. *L. C. Packer*

581 Design Progress in General Purpose Fractional Horsepower Motors. *H. L. Wiss*

525 A New Increased Capacity High-Speed Three-Phase Oil Circuit Recloser. *R. W. Bathke*

543 Economics of 13 Kv for Highly Developed 4-Kv Urban Areas. *R. P. Huber*

549 Economic Comparison of Secondary Voltages for Residential Areas. *H. E. Lokay*

528 Load Switching's Future—Unlimited. *John Conrad*

550 Magnetic Amplifier Dimming Circuits for Fluorescent Lamps. *H. W. Lord*

524 Servo-Positioning for a Non-Glare Headlight System. *Harold Bahm*

545 Fluorescent Lamp Ballast Noise. *R. A. Hunn*

562 Noise Evaluation of Luminous Tube Transformers. *L. C. Rademaker*

Harvey F. Mack, Printer of Electrical Engineering, Dies

Electrical Engineering regrets the death of Harvey F. Mack, chairman of the board of directors of the Mack Printing Company, Easton, Pa., who died at the age of 77.

Mr. Mack was born in Phillipsburg, N. J., November 6, 1878. He entered the printing business in 1900, and acquired the Eschenbach Printing Company, forerunner of the Mack Printing Company, in 1905. He served as president of the company until March 1956, when he became chairman of the board. As a prominent leader in civic and charitable affairs, Mr. Mack was principally interested in the Easton YMCA and YWCA, the Community Chest, and the Easton Area Chamber of Commerce. He was also a member of several scientific organizations, including the American Chemical Society and the Chemists Club of New York City.

During his lifetime, a number of groups and organizations paid tribute to Mr. Mack. Lafayette College awarded him the honorary degree of doctor of humane letters at Founders Day exercises in 1949. In January 1952, he received the Kiwanis International Legion of Honor Award. In April 1955, the

H. F. Mack

Easton Area Sales Executives presented a special award to Mr. Mack for his contribution to the business and civic life of his community. He was also honored on other occasions by the employees of his company, the American Legion, and the American Chemical Society.

The publications of the American Chemical Society and of several of the founder engineering societies are printed by the Mack Printing Company. *Electrical Engineering* and AIEE *Transactions* have been printed by this company since 1933.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Radio Communications Systems (E. D. Becken, *Chairman;* R. D. Campbell, *Vice-Chairman;* David Talley, *Secretary*). The Committee has recognized the lack of adequate technical coverage of maintenance and reliability of communications equipment. Coverage of technical operation of equipment units, as well as systems, have been generally adequate, but insufficient attention has been given to maintenance and reliability which are assuming greater importance because of the increasing complexity. Consequently, plans are being rapidly developed for joint sessions with the Wire Communications, Telegraph, and Television and Aural Broadcasting Committees to cover various aspects of maintenance and reliability both from the operator's and the manufacturer's viewpoint. This singling out of a technical area that has had incomplete coverage in the past has been found by the Committee to be productive of interest and additional papers. Considerable attention was given to the possibility of reorganizing the Committee into several permanent subcommittees, in order to cover all phases of the radio communications field. However, this was discarded in favor of continuing the present single committee structure, and the institution of special temporary committees, to explore and expedite the development of papers on a specific subject. It

Future AIEE Meetings

AIEE-IRA-ISA Telemetering Conference*
Ambassador Hotel, Los Angeles, Calif.
August 20–21, 1956

AIEE-IRE Industrial Electronics Conference
Hotel Manger, Cleveland, Ohio
September 24–25 1956
(*Final date for †TP—closed, ‡CP Syn.—July 12, CPMs—July 20*)

AIEE-IRE-RETMA National Electronics Conference
Chicago Ill.
October 1–3, 1956
(*Final date for †TP—July 3, ‡CP Syn.—July 19, CPMs—July 27*)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 1–5, 1956
(*Final date for †TP—June 4, ‡CP Syn.—July 19, CPMs—July 27*)

AIEE-IRE Conference of Magnetism and Magnetic Materials
Hotel Statler, Boston, Mass.
October 16–18, 1956
(*Final date for †TP—July 19, ‡CP Syn.—Aug. 3, CPMs—Aug. 13*)

Machine Tool Conference
Sheraton Gibson Hotel, Cincinnati, Ohio
October 22–24, 1956
(*Final date for †TP—July 25, ‡CP Syn.—Aug. 8, CPMs—Aug. 17*)

AIEE-IRE-ISA Conference on Electronic Technology in Medicine and Biology
Gov. Clinton Hotel, New York, N. Y.
November 7–9, 1956
(*Final date for †TP—Aug. 10, ‡CP Syn.—Aug. 24, CPMs—Sept. 4*)

AIEE-IRE Eastern Joint Computer Conference
Hotel New Yorker, New York, N. Y.
December 10–12, 1956
(*Final date for †TP—Sept. 12, ‡CP Syn.—Sept. 26, CPMs—Oct. 5*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1957
(*Final date for †TP—Oct. 24, ‡CP Syn.—Nov. 8, CPMs—Nov. 16*)

North Eastern District Meeting
Pittsfield, Mass.
May 1–3, 1957
(*Final date for †TP—Feb. 1, §DP Syn.—Feb. 15, DPMs—Feb. 25*)

Middle Eastern District Meeting
Dayton, Ohio
May 7–9, 1957
(*Final date for †TP—Feb. 8, §DP Syn.—Feb. 22, DPMs—March 5*)

Summer General Meeting
Montreal, Que., Canada
June 24–28, 1957
(*Final date for †TP—March 26, ‡CP Syn.—April 11, CPMs—April 19*)

*Final date for submitting papers—closed
†TP—Transactions paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
(The CPSyn. date is 10 days before the CPMs date)
§DP Syn.—District Synopsis
DPMs—District Manuscript
(The DPSyn. date is 10 days before the DPMs date)

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

is felt that this organizational approach provides desirable flexibility. European engineers have been approached as to the possibility of presenting papers at an AIEE technical session, describing European communications systems. Since the European systems for both telegraphy and telephony differ in many aspects with each other, as well as with the systems in the United States, it is expected that a technical session on foreign communications systems would prove most interesting.

Industry Division

Committee on Industrial Control (L. H. Matthias, *Chairman;* J. W. Picking, *Vice-Chairman;* R. W. Moore, *Secretary*). The Subcommittee on Test Codes has submitted to the main committee the final section of a test code for industrial control equipment. On the acceptance of this final section by the main committee, it will be combined with those sections previously approved to form the complete test code. This Subcommittee, under the chairmanship of C. T. Evans, has been active in the preparation of the test code for several years. The Subcommittee on Electronic Control, under W. H. Elliott, has submitted its Proposed Standard for Electronic D-C Motor Control to the main committee for comment and criticism. This proposed standard, in the form of a conference paper, was presented for general comment by J. J. Moyer at the Winter General Meeting in New York, N. Y. The Standards Subcommittee has recently been reorganized with new membership under the chairmanship of E. F. Mekelburg.

Power Division

Committee on Protective Devices (E. G. Norell, *Chairman;* E. M. Hunter, *Vice-Chairman;* K. H. Kidd, *Secretary*). The Revised Report on Standards for Valve and Expulsion Type Lightning Arresters, AIEE Standard No. 28B, has been approved by the Standards Committee and has been published for comment and criticism as a proposed revision of AIEE Standard No. 28 (ASA *C-62.1-1944*). The ASA Committee No. C-62 has been active in combining this report and the National Electrical Manufacturers Association Lightning Arrester Standard to form a new American Standard for Lightning Arresters. It is expected that the proposed American Standard will change the classification of lightning arresters to the following: Station-Type Valve Arresters; Intermediate-Type Valve Arresters, recommended to replace the term "Line Type Arrester"; Distribution-Type Valve Arresters; Distribution-Type Expulsion Arresters; Secondary-Type Valve Arresters; and Protector-Tubes, recommended to replace the term "Line Expulsion Arresters". At a Protective Devices Committee meeting in Cleveland, Ohio, on April 12, 1956, it was agreed that the Protective Devices Committee will not oppose the arrester type classification as set forth in the foregoing. It was also agreed that the Protective Devices Committee would not oppose the reference to both power factor and X/R ratios in the sections dealing with duty cycle testing of expulsion arresters. The proposed new American Standard *C-62* has been issued for ballot and will probably have been approved by the time this article is published. Other working groups are exploring the following subjects: Lightning Protection of Aerial Cable, Lightning Protection of Multicircuit Substations, and Surge Protection of Rotating Machines. The working group preparing a report on the Lightning Arrester Application Guide has been reactivated and has reconciled most of its differences. The report is expected to be ready for the Fall General Meeting. The working group on the revision of AIEE Standard No. 32 on Neutral Grounding Devices has continued to function and one of its most difficult problems has been to decide on a method of calculating temperature rises during short circuits. A method similar to that used for transformers is under consideration. A liaison member has been appointed to the substations working group on Potential Gradients in Grounding Systems within Substations. A request has been made that additional information be obtained on the problem of protecting control and communication cables from the high potentials which may exist on the substation ground mat during ground faults. These potentials could rupture the low voltage cable insulation and damage control and communication equipment and possibly cause faulty relay operation. At some hydro sites, the generating station and the switchyard may be as much as a mile apart with appreciable differences in ground potential.

Science and Electronics Division

Committee on Metallic Rectifiers (D. E. Truckess, *Chairman;* E. A. Harty, *Vice-Chairman;* L. W. Burton, *Secretary*). Two members of this committee, E. A. Harty and I. R. Smith, are scheduled to attend the International Electrotechnical Commission Meeting in Munich, Germany, from June 26 to July 6, to represent the Metallic (Semi-Conductor) Rectifier Industry on Committee 22-2 as U. S. delegates. In preparation for this meeting, a joint AIEE-National Electrical Manufacturers Association (NEMA) Meeting was held in Cleveland, Ohio, May 15–16, with delegates representing a cross-section of the industry, to discuss the second edition of proposed International Electrotechnical Commission Standards. These standards have been worked out by using AIEE and NEMA issued standards or guides. Over 10 countries will be represented at this international meeting. NEMA is sponsoring the delegates. A full report of the Munich meeting will be the subject of an AIEE paper to be presented next May, during a Rectifier Conference sponsored by the Committees on Power Conversion and Metallic (Semi-Conductor) Rectifiers.

Committee on Nucleonics (W. E. Barbour, Jr., *Chairman;* P. N. Ross, *Vice-Chairman;* T. S. Gray, *Secretary*). At an AIEE joint Nucleonics and Instruments and Measurements (I and M) meeting during the Nuclear Congress sponsored by the Engineers Joint Council along with some 27 professional societies in Cleveland, Ohio, in December, and subsequently at the Winter General Meeting, the Instrumentation Subcommittee membership was made to include the same people. With subsequent upgrading of I and M to division status, the AIEE activities in nuclear instrumentation will now come under a new Committee on Nucleonic and Radiation Instruments, instead of the former joint subcommittees. At the Winter General Meeting, the need for a definitive program for the electrical engineering profession on the Effects of Radiation on Materials Used in the Electrical Industry was considered desirable. Accordingly, a subcommittee was set up to cover especially the mechanism of changes that take place in materials under radiation which affect their physical, chemical, and electrical properties. Although it is recognized that a Committee on Dielectrics Subcommittee was already concerning itself with radiation effects on dielectrics, it was felt that other changes, both deleterious and beneficial, are of interest to electrical engineers. Any overlapping of work of the two subcommittees can be resolved at a later date. The Committee on Nucleonics is participating with some 180 organizations on standardization in the nuclear field. This general standards program is being co-ordinated by the American Standards Association. It is contemplated that the Committee will again work on the program and cosponsorship with other societies of a Second Nuclear Congress, now scheduled for Philadelphia, Pa., March 10–16, 1957. The Nuclear Instruments Subcommittee again assisted in the sponsorship of the Scintillation Counter Symposium, February 28–29 in Washington, D. C. At the suggestion of *Electrical Engineering*, the Committee has been considering a revised publication of "Elements of Nucleonics for Engineers," which was published in book

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

form, comprising 11 papers first appearing in successive issues of *Electrical Engineering*. Declassification and advances in the nuclear art have rendered much of the 1949 publication out of date. The title was revised to be directed specifically to electrical engineers. A questionnaire soliciting the ideas of all Nucleonics Committee members have been sent out and very nearly 100 per cent have replied, many supplying valuable detailed ideas and potential authors for the parts requiring revision. This material was summarized by the chairman for presentation to the Committee in San Francisco, Calif., in June for action to implement the preparation of new material.

AIEE FELLOWS ELECTED

Harald Norinder* (M '34), professor of electrophysics and director of the Institutet for Hogspanningsforskning, University of Uppsala, Uppsala, Sweden, has been transferred to the grade of Fellow in the AIEE "...for his pre-eminent contributions to lightning protection of electrical circuits and to high-voltage power transmission." Dr. Norinder was born in Norrkoping, Sweden, March 3, 1888. He received his doctorate from Uppsala University in 1921. Dr. Norinder is one of the world's outstanding authorities on the subject of lightning discharges, wave fronts, and protective measures for power, for telephone lines, and for buildings and other constructions against lightning damage. By investigations sponsored by the Royal Swedish Board of Waterfalls—State Power Board he was, in 1920, the first to apply cathode-ray oscillographic technique to the researches of electrophysical conditions of lightning discharges. In 1925, by using a cathode-ray oscillograph constructed with the special Norinder relay which he invented, he was able for the first time to discover the variation features of lightning surges on high voltage transmission lines. As a result of a foundation and a contribution partially from the Swedish state and partially from the Swedish State Power Board, the Institutet for Hospanningsforskning was established at the University of Uppsala. In relation to the Institutet, the professorship of electrophysics was created at the university, and Dr. Norinder was called as the first holder to this new chair in 1932. He became at the same time the Director of the new Institutet, which was built under his

Harald Norinder

personal leadership and supervision. Dr. Norinder has visited the United States frequently to advise on measures concerning lightning protection and has been an advisor to the power authorities in many other countries on such matters. He is a member of the Royal Society of Sciences, Uppsala, and a Fellow of the Royal Swedish Academy of Sciences, and the Royal Swedish Academy of Technical Science.

AIEE PERSONALITIES

C. R. Burrows (AM '26, F '45), director of the School of Electrical Engineering, Cornell University, Ithaca, N. Y., will join the Ford Instrument Company, Division of Sperry Rand Corporation, New York, N. Y., July 1. He will become vice-president for engineering, heading all engineering, development, and research. Dr. Burrows received a bachelor's degree in electrical engineering from the University of Michigan in 1924, and a professional degree in 1935. In 1938, he was awarded a doctorate in physics by Columbia University. Besides his duties at Cornell, Dr. Burrows has been associate chief scientist of the General Electric Company's Advanced Electronics Center. During World War II, he was chairman of the radio wave propagation committee of the National Research and Development Council. Just prior to the war, he worked on the proximity fuse and later on the development of radar and counter-measure equipment. For 21 years, he specialized in research in advanced electronics at the Bell Telephone Laboratories and holds several patents. During the last 10 years, he has guided Cornell graduate students doing work in this field. Dr. Burrows is vice-president of the International Scientific Radio Union, and a past president, Fellow, and director of the Institute of Radio Engineers. He is a Fellow of the American Physical Society and a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He has served on the following AIEE Committees: Basic Sciences (1947–52), and Research (1947–55).

J. F. Dexter (AM '41, M '51), manager of the electrical section, Product Engineering Laboratories, Dow Corning Corporation, Midland, Mich., will represent the American National Committee of the International Electrotechnical Commission (IEC) at its annual meeting in Munich, Germany, June 26 to July 6. Mr. Dexter was graduated in 1940 from Texas A and M College with a bachelor of science degree in electrical engineering. Following graduation, he was employed in the electrical engineering design department of The Dow Chemical Company. In 1943, he was commissioned an Ensign in the U. S. Navy and until 1945, journeyed extensively in the Near East studying the design and effectiveness of mine warfare ordnance. He joined the Product Engineering Laboratories of Dow Corning in 1947. While in Europe, he will act as presiding chairman of the IEC working group on the evaluation of electrical insulating materials. He also will lecture at several scientific meetings in England, France, Holland, and Scandinavia, describing current developments in the field of silicone electrical insulation. Mr. Dexter has served on the following AIEE Committees: Basic Sciences (1952–55), Transformers (1952–53), and Dielectrics (1955–56).

J. H. Blankenbuehler (AM '31, F '48), design engineer, Hobart Brothers Company, Troy, Ohio, has been elected a director-at-large of the American Welding Society. Mr. Blankenbuehler graduated from Lehigh University with a degree of electrical engineer. He worked for the Westinghouse Electric Corporation, Pittsburgh, Pa., for 23 years, starting as a design engineer and advancing to manager of welding apparatus engineering. Since 1940, he has been with Hobart Brothers Company as design engineer. Mr. Blankenbuehler is a member of the American Ordnance Association, American Society for Metals, the Ohio Society of Professional Engineers, Tau Beta Pi, and is a registered professional engineer in Pennsylvania and Ohio. He has served on the following AIEE Committees: Electric Welding (1931–34, 1936–43, 1949–56); and Air Transportation (1948–53).

H. H. Fahnoe (AM '35, M '49), engineering manager for switchgear distribution apparatus, Westinghouse Electric Corporation, East Pittsburgh, Pa., has joined S and C Electric Company, Chicago, Ill., to serve as manager of administrative engineering. A 1934 graduate of Cornell University, Mr. Fahnoe joined Westinghouse as a graduate student in 1935, and was named design engineer in 1936. He became manager of the switchgear distribution apparatus department in 1950. During his 21 years in the industry, he has contributed significantly to the art of circuit interruption and protection, particularly concerning high voltage power fuses. Mr. Fahnoe is active in several National Electrical Manufacturers Association groups.

Morris Brenner (AM '46, M '54), assistant engineer, technical service department, Burndy Engineering Company, Norwalk, Conn., has been appointed chief engineer, Penn-Union Electric Corporation, Erie, Pa. He will be in charge of all engineering activities. Before joining Penn-Union, Mr. Brenner was engaged in the engineering of electrical connectors with the Burndy Engineering Company ever since receiving

* Dr. Norinder's transfer to grade of Fellow was approved by the Board of Directors on April 3, 1956.

Morris Brenner

his bachelor of science degree in electrical engineering from New York University in 1946. He has recently been acting as staff advisor to the assistant chief engineer at Burndy, and as a special consultant to the copper industry. Mr. Brenner has 10 years of experience in connector application and design, and in the training of technical personnel. He is the author of over 20 engineering articles and papers appearing in leading technical and professional journals and the associate editor of the third edition of the recently published "Handbook of Applied Mathematics." A professional engineer and the holder of a master's degree in administrative engineering, Mr. Brenner was chairman of the Registrations Committee for the past two Winter General Meetings of the AIEE as well as an active member of the Education and Program Committee of the New York Section. He is a member of Eta Kappa Nu and Tau Beta Pi.

H. S. Renne (AM '45, M '52), technical editor, electronics group, Ziff-Davis Publishing Company, New York, N. Y., has joined Bell Telephone Laboratories, New York, N. Y., as technical information supervisor. In his new post, Mr. Renne will serve the technical and trade press, providing information on Bell Laboratories' research and development activities. Mr. Renne was graduated from Kalamazoo College with a bachelor of arts degree in physics in 1934, and received a master of science degree in physics in 1938 from Syracuse University. Following this, he was employed by Underwriters' Laboratories, Inc., as assistant electrical engineer. In 1942, he joined the Illinois Institute of Technology as an instructor and supervisor in the pre-radar program, and in 1943, he became a physics instructor on the regular staff. He joined Ziff-Davis Publishing Company early in 1944, and has been associated with *Radio and Television News* and *Popular Electronics*. Mr. Renne is a member of the Institute of Radio Engineers, Sigma Pi Sigma, and an associate member of Sigma Xi.

OBITUARIES

Malcolm Strong McIlroy (M '36), professor of electrical engineering, Cornell University, Ithaca, N. Y., died recently at the age of 53. Prof. McIlroy was born in Rochester, N. Y., August 28, 1903. He was graduated from Cornell in 1923 with a bachelor of science degree in electrical engineering. He then served with the General Electric Company as a test engineer and with the Brooklyn Manhattan Transit Corporation as equipment inspector. In 1926, he was employed by the Central Hudson Gas and Electric Company, Poughkeepsie, N. Y., where he became successively distribution engineer, district engineer, and district superintendent. In 1937, he joined the staff of Massachusetts Institute of Technology (MIT), serving as instructor and assistant professor of electrical engineering. During World War II, he was assistant director of the MIT Radar School. He was awarded the doctor of science degree by MIT in 1947. That same year, he became a member of the faculty of Cornell University. Prof. McIlroy was widely known for his development of the fluid network analyzer. For this contribution, he was awarded the John M. Goodele prize of the American Water Works Association in 1949. Prof. McIlroy was a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi. He served on the AIEE Computing Devices Committee (1949–52).

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of May 17, 1956, recommended the following applicants for transfer. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Brennan, F. L., station design engineer, Boston Edison Co., Boston, Mass.
Bryans, H. T., genl. superintendent, station operating dept., Philadelphia Electric Co., Philadelphia, Pa.
Callow, C. W., electrical engineer, Sacramento Municipal District, Sacramento, Calif.
Campbell, A. R., area sales manager, Westinghouse Electric Corp., Chicago, Ill.
Carter, R. S., Jr., power engineer, Atomic Energy Commission, Aiken, S. C.
Coley, S. F., field engineer, Westinghouse Electric Corp., St. Louis, Mo.
Fligor, L. G., personnel supervisor, Southwestern Bell Telephone Co., St. Louis, Mo.
Galiyano, M. C., project engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Gaston, L. D., power engineer, International Cooperation Administration, State Dept., Washington, D. C.
Gilchrist, A. D., vice president, The Leece-Neville Co., Cleveland, Ohio.
Hall, H. W., standards tester, Pennsylvania Power & Light Co., Allentown, Pa.
Hammond, S. B., assistant professor, University of Utah, Salt Lake City, Utah.
Haupt, L. O., process supervisor, Proctor & Gamble Mfg. Co., Sacramento, Calif.
Jambro, J. D., chief engineer, International Graphite & Electrode Div., Niagara Falls, N. Y.
Jensen, L. E., engineer, Illinois Power Co., Decatur, Ill.
Johnson, L. W., project engineer, Westinghouse Electric International Co., New York, N. Y.
Kister, N. M., engineering assistant, Gilbert Associates, Inc., Reading, Pa.
Klokow, R. E., design engineer, Westinghouse Electric Corp., Lima, Ohio.
Koen, H. R., Jr., power supply coordinator, Southern Services, Inc., Birmingham, Ala.
Kraus, H. F., electrical engineer, U. S. Navy Public Works Office, New Orleans, La.
Lambert, H. R., supervisory engineer, Westinghouse Electric Corp., Baltimore, Md.
MacDonald, L. L., senior engineer, Public Service Electric & Gas Co., Newark, N. J.
Maxwell, R. F., Jr., project engineer, Westinghouse Electric Corp., Baltimore, Md.
Mayers, R. W., electrical engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Minx, C. C., senior engineer, Southwestern Bell Telephone Co., St. Louis, Mo.
Morrison, D., chief engineer, General Tire Corp., Athens, Ga.
Parnell, J., research engineer, Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.
Reitan, D. K., assistant professor of electrical engineering, University of Wisconsin, Madison, Wis.
Riaz, M., assistant professor, Massachusetts Institute of Technology, Cambridge, Mass.
Sandberg, M. C., vice-president, Control Corp., Minneapolis, Minn.
Scribner, B. D., engineer, Southern New England Telephone Co., New Haven, Conn.
Smith, H. W., electrical engineer, Aluminum Co. of America, Vancouver, Wash.
Smith, R. W., residential & farm sales manager, General Public Utilities System Div., Pennsylvania Electric Co., Reading, Pa.
Sprague, C. H., director, International Correspondence School, Scranton, Pa.
Standring, J. M., Jr., customer station engineer, American Tel. & Tel. Co., New York, N. Y.
Subramanian, G., officer-in-charge, Hindustan Cables, Ltd., West Bengal, India.
Swenk, A. L., senior engineer, Public Service Electric & Gas Co., Newark, N. J.
Timmel, F. G., supervising engineer, air arm div., Westinghouse Electric Corp., Baltimore, Md.
Valenta, M. F., project engineer, Westinghouse Electric Corp., Baltimore, Md.
Walton, R. E., vice-president & chief engineer, Sweney Electric Co., Gary, Ind.
Wearly, W. L., executive vice-president, Joy Manufacturing Co., Pittsburgh, Pa.
Weiner, M. C., field service engineer, Westinghouse Electric Co., St. Louis, Mo.
Weiss, A. E., assistant electrical engineer, Pioneer Service & Engineering Co., Chicago, Ill.
Welch, G. L., manager, Mid-Western region, Westinghouse Electric Corp., Chicago, Ill.
Wilcox, H. K., division manager, I-T-E Circuit Breaker Co., South Greensburg, Pa.
Wilhoit, G. D., electric service supervisor, Westinghouse Electric Corp., Huntington, Ill.
Williams, S. T., electrical engineer, General Public Utilities System, Reading, Pa.
Zavitz, E., stations Engineer, The Detroit Edison Co. Detroit, Mich.

48 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before July 25, 1956, or September 25, 1956, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Alden, C. R., Ohio Northern University, Ada, Ohio.
Anthony, G., U. S. Bureau of Reclamation, Sacramento, Calif.
Bernt, A. C., Federal Pacific Electric Co., Scranton, Pa.
Bockman, T. V., Plantation Pipe Line Co., Atlanta, Ga.
Bonneson, E. J., American Tel. & Tel. Co., New York, N. Y.
Brown, B. C., Chemical Construction Corp., New York, N. Y.
Dingley, E. N., Jr., National Security Agency, Washington, D. C.
Doup, C. N., McDonnell Aircraft Corp., St. Louis, Mo.
Dresner, F. E., Packard Electric Division, GMC, Warren, Ohio
Eubanks, J. M., University of Miami, Coral Gables, Fla.
Fister, F. M., Southern Bell Tel. & Tel. Co., New Orleans, La.
Freeborn, O. W., Tobe Deutschmann Corp., Norwood, Mass.
Glatz, G. E., S. A. des Ateliers de Secheron, Geneva, Switzerland.
Hailey, A. R. T., Canadian General Electric Co., Peterborough, Ontario, Canada.
Hamid, L. L., Ferria & Hamid, St. Louis, Mo.
Hansen, A., Louis Allis Co., Milwaukee, Wis.
Hauck, W. J., Rural Electrification Administration, Portland, Ore.
Hodson, L. A., Stromberg-Carlson Co., Rochester, N. Y.
Hood, H. W., 312 Venning St., Mt. Pleasant, S. C.
Jepson, C. M., New England Tel. & Tel. Co., Manchester, N. H.
Johanson, C. G., Town of South Hadley, Mass.
Munich, F. E., Western Union Telegraph Co., New York, N. Y.
Neblett, R. S., General Electric Co., Schenectady, N. Y.
Newbold, W. F., Minneapolis-Honeywell Reg. Co Brown Instrument Div., Philadelphia, Pa.
Ostaff, W. A. (re-election), National Bureau of Standards, Washington, D. C.
Parker, R. M., West Virginia Pulp & Paper Co., Charleston, S. C.
Perkins, E. H., M. T. S. Bell Telephone Laboratories, Lawrence, Mass.
Robertson, P. A., Bechtel Corp., San Francisco, Calif.
Scott, W. M., Jr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Shivshanker, P. G., Government of Bihar Electricity Department, Musaffarpur, N. Bihar, India.
Skillman, C. A., Public Service Electric & Gas Co. of New Jersey, Maplewood, N. J.
Uloth, M. M., Canadian General Electric Co., Peterborough, Ontario, Canada.
Vande Noord, G. J., General Electric Co., Atlanta, Ga.
Wright, D. S., Jr., Quinton Engineers Ltd., Los Angeles, Calif.
Wallenstein, G. D., Lenkurt Electric Co., San Carlos, Calif.
Williamson, G. V., Union Electric Co., St. Louis, Mo.

36 to grade of Member

IN EDUCATIONAL CIRCLES

ACTIVITIES AND INTERESTS

AIEE-IRE Hold Annual Joint Student Activities Day

THE SECOND ANNUAL Joint AIEE-IRE Student Activities Day for the metropolitan New York area was held at Rutgers University April 27. The affair was sponsored by AIEE District 3, IRE Region 2, and New York Sections of AIEE and IRE.

Four prize papers were selected by the judges for oral presentation during the afternoon. The first prize of $50 was awarded to C. A. von Urff of New York University for his paper on a "Color Bar Generator," second prize of $25 was awarded to G. A. Laureyns, a senior in the electrical engineering department at Rutgers University, for his paper on "The Design of a Miniaturized Pi Filter," third prize of $15 was given to Harold Gordy of New York University for his paper on "A Simple Servo Function Generator," and fourth prize of $10 went to W. J. Harrold of Brooklyn Polytechnic Institute for his paper on "The Design of an Inexpensive Differential Analyzer." In addition to the aforementioned prize winners, Richard Watson of Stevens Institute was awarded a $50 prize for his demonstration of a "Projection Color T.V. System."

At the General Meeting, in the afternoon, 300 students from the 10 colleges in the New York area were welcomed by Dean Easton of Rutgers University. Following the presentation of papers, there was a tour of the electrical laboratories, and dinner at 6:00 p.m. in the University Commons. After dinner, J. R. Logie of the Bell Telephone Laboratories presented a paper which included slides and a color motion picture on "Nike—Guided Missiles."

All students in attendance at the session and at the dinner were the guests of the New York Sections of AIEE and IRE.

Courtesy F. J. Higgins

C. A. VON URFF, JR. (*right*), New York University, winner of the District 3 Prize Paper Contest first prize of $50 plus a one-week all-expense trip to the AIEE Summer General Meeting at San Francisco, Calif. is congratulated by Prof. R. T. Weil, Jr. (*left*) of Manhattan College, chairman of the New York Section of AIEE who presented the awards on behalf of the New York Sections of AIEE and IRE. Looking on is Richard Watson (*center*), Stevens Institute of Technology, who won a $50 prize for first place in a demonstration contest.

District 6 Holds Student Branch Conference

The District 6 Conference and Student Paper Contest was held at Colorado A and M Fort Collins, Colo., April 13–14. Eight papers were presented by students from South Dakota School of Mines and Technology, University of Colorado, University of Denver, and University of Nebraska. The winning papers were announced at the evening banquet on April 13. The University of Denver Student Branch received the prize for the highest percentage of student members. A prize for number of students times miles traveled was won by South Dakota School of Mines and Technology. A total of 145 students and faculty members attended the paper contest.

The winners of the paper contest were: "An Electromechanical Tic-Tac-Toe Machine," first prize, G. D. Green and L. M. Hill of the University of Colorado; "Concepts of Electronic Noise," second prize, T. M. McCalla, Jr. of the University of Nebraska; and "The Gas Turbine as a Prime Mover for Electric Power Generation," third prize, Al Zeman, University of Colorado.

After the paper contest, inspection trips were made to the Flatiron Power Plant and Switching Station of the Colorado Big Thompson Project and to the Ideal Cement Company plant.

Judges for the written papers were Clarence Talsma, D. L. Renner, and R. J. Berti of the Nebraska Section. Oral judges were H. K. Polk, J. C. Livesay, and C. A. Kemp of the Denver Section. R. J. Bertorello, Student Branch Chairman, was in charge of the paper contest.

The business meeting of the counselors and Student Branch chairmen was held Saturday morning April 14, with Vice-President E. R. Jones presiding. The conference followed the usual rotation procedure. Prof. A. R. Edison of the University of Nebraska was elected chairman of the District Committee on Student Activities to succeed Prof. P. H. Lindon of Colorado A and M. The University of Nebraska was selected for the 1957 Spring Conference.

North West District Paper Contest Held May 12

The Student Prize Paper Contest of the North West District was held at the University of Washington in Seattle, Wash., May 12, under the joint auspices of the Seattle Section and the University of Washington Student Branch. First prize winner was A. N. Blankenship of the University of Washington for his paper "Three-Phase Slave Motor."

The North West District has established a student activity fund, financed by section

Courtesy C. B. Brown

SOME OF THOSE ATTENDING the North West District Student Prize Paper Contest were: back row (*left to right*) F. D. Robbins, chairman, North West District Committee on Student Affairs, and counselor, University of Washington; Rev. F. P. Wood, S. J., counselor, Seattle University; R. E. Stephenson, counselor, University of Utah; A. L. Betts, counselor, State College of Washington; W. R. Parish, counselor, University of Idaho; L. R. Kersey, counselor, University of British Columbia; L. N. Stone, counselor, Oregon State College; Ted Waddell, University of Idaho. Second row (*left to right*) Dan Decker, incoming chairman, University of Washington Student Branch; E. W. Kimbark, Dean, College of Engineering, Seattle University, chairman of Prize Paper Judging Committee; J. M. Olson, Seattle, judge; E. M. Lee, Seattle, judge. Front row (*left to right*) Clarence Giese, chairman University of Washington Student Branch; J. A. Cramb, University of British Columbia; R. M. O'Brien, Oregon State College; A. N. Blankenship, (with trophy), University of Washington, North West District Student Branch first prize winner; J. C. Elsey, University of Utah; B. W. Hayes, University of Idaho; and Jack Hicks, State College of Washington.

contributions, as a means to increase the incentive for the preparation of student papers. This fund was used to provide a trophy which was also awarded to the first prize winner. This trophy will be rotated to the winning branches at future District competitions. The fund, with an additional contribution from Seattle Section, was also used to provide prizes for other contestants, whose papers were of uniformly high caliber.

Other students who presented papers were: B. W. Hayes, University of Idaho, "A Report on a Ripple Free Unipolar Generator," second prize; R. M. O'Brien, Oregon State College, "An Approximation of the Performance of a Torque-Saturation System," third prize; J. C. Elsey, University of Utah, "A Simple Relay Digital Computer," fourth prize; J. A. Cramb, University of British Columbia, "The Canadian Westinghouse Magamp-Regulated Winder Drive," fifth prize; and Jack Hicks, State College of Washington, "Selective Feedback in Audio Amplifiers," sixth prize.

H. R. Loew, chairman of the Seattle Section, acted as master of ceremonies. R. E. Kistler, Director, and C. B. Brown, secretary of the North West District, were among those who attended the contest.

PENNSYLVANIA POWER and Light Company played host to outstanding college engineering students and AIEE officials, May 10–11. G. W. Robbins (*right*), PP and L chief local system operator, explains the complex operating board at the Company's Allentown service depot to (*left to right*) A. P. Powell, district chairman of students for AIEE; C. T. Pearce, District No. 2 vice-president; C. G. Smith, Princeton University; R. S. Gaines, U. S. Naval Academy Student Branch chairman; and Thomas Rasser, Villanova University.

1956 College Blue Book Published

"The College Blue Book," a standard work of reference of higher education in the United States, has recently been published. This 1956 eighth edition replaces the seventh which was printed in 1953. The volume contains information about every institution of higher learning requiring graduation from a secondary school for admission. It includes a section on engineering schools by W. L. Collins, secretary American Society for Engineering Education, and lists the engineering curricula accredited by Engineers Council for Professional Development. Other sections of particular interest to engineers are devoted to technical institutions and to scholarships, foundations, and research. The price of this 688-page book is $12. It has been edited and published by C. E. Burckel, P. O. Box 311, Yonkers-on-Hudson, N. Y.

Pennsylvania Power and Light Company Host to Students

On May 10, Pennsylvania Power and Light Company (PP and L) welcomed to its service area several participants in the recent AIEE student prize paper contest.

Students from AIEE District No. 2, composed of 21 colleges in Pennsylvania, the District of Columbia, Delaware, Maryland, New Jersey, West Virginia, and Ohio, participated in the competition held in Pittsburgh, Pa., April 27–28. The tour of the local utility's properties was made by students, R. S. Gaines, Midshipman 1/c, U. S. Naval Academy, Annapolis, Md.; Thomas Rasser, Villanova University; and C. G. Smith, Princeton University; and counselors, H. M. Chandler, Jr., Princeton; and J. B. Clothier, Villanova. Representing AIEE District No. 2 were Vice-President C. T. Pearce, regional engineering and service manager for Westinghouse, Philadelphia, Pa.; and A. P. Powell, professor of electrical engineering at the Pennsylvania State University and district chairman of student activities for AIEE.

The tour, which gave these undergraduates and counselors a behind-the-scenes glimpse of an electric utility at work, began at the PP and L general office building in Allentown, Pa. The students were greeted by H. Ferguson, the utility's vice-president, operating; W. B. Morton, PP and L's electrical engineer and chairman of AIEE Committee on Student Branches; and other company officials.

After touring the modernized general office building, the group visited the local system operator's office at the Allentown service depot, and Hosensack 220-kv interconnection substation. This was followed by dinner at Lehigh Valley Club, Allentown, where the students saw films on PP and L construction activities and heard company engineers speak on system planning, electrical research and development, methods and problems, telemetering, supervisory control, and carrier systems.

The following day, May 11, the visitors toured PP and L's modern outdoor-type

power plant at Martins Creek. Plant supervisory personnel, serving as guides, explained the many operating and construction features of the power station.

Student Prize Paper Contest Held by District 11

On Friday, May 11, District 11 held its annual convention and student prize paper contest at Case Institute of Technology, Cleveland, Ohio. Attendance was well over 100 and included all the Executive Committee members. Six of the nine schools were represented by students, while the Cleveland section filled in to make the event a huge success.

After an address by Dean Elmer Hutchisson of the Case Graduate School, the paper presentation began and lasted until 11:30 a.m., when the Executive Committee joined

AT THE DISTRICT 11 Student Prize Paper award presentation (*left to right*) J. C. Strausbourger, vice-president District 11; K. B. McEachron, Jr., dean of the Undergraduate School, Case Institute of Technology; and R. G. Colclaser, University of Cincinnati, first place winner.

students at an informal lunch in the Student Union.

The presentation of the remaining papers in the afternoon was followed by a conducted tour of the new William E. Wickenden Electrical Engineering Building, including a closed circuit television demonstration in the sound recording and acoustics laboratory.

In the evening, K. B. McEachron (F '51), dean of the Undergraduate School at Case, was master of ceremonies at a banquet. He introduced J. C. Strasbourger of the Cleveland Electric Illuminating Company and vice-president of District 11, who presented the District and local awards. The winners of the district contest were R. G. Colclaser, University of Cincinnati, first place, "An Electrical Analogue of a Servomechanism"; Hugh Bayless, Fenn College, second place, "A Modified Multichannel Magnetic Sound Recording Technique for the Small Motion Picture Studio"; and J. R. Watt, University of Toledo, third place, "Control Systems for Regulation of

AT A RECENT MEETING of the AIEE Student Branch at the Milwaukee School of Engineering (*left to right*) R. J. Ungrodt, faculty advisor of the AIEE Student Branch; J. W. Becker, A. C. Spark Plug, Milwaukee; G. L. Amacher, outgoing chairman of the AIEE student branch; and E. F. Zimmer, incoming chairman, discuss a major point of Mr. Becker's talk.

D-C Generators." J. H. Edwards of the Ohio Power Company presented a tour of the installations of the Ohio Power Company to the winners of the District competition. Clarence Beller of the Cleveland Electric Illuminating Company was introduced and offered a similar trip to the winners next year. The concluding event was a stereophonic sound demonstration given by Kenneth Hamman of the Cleveland Recording Company.

AIEE Student Branch Meeting at MSOE

Members of the AIEE Student Branch at the Milwaukee (Wis.) School of Engineering (MSOE), heard a talk on "Radio Telemetry" by J. W. Becker, senior research engineer of the testing engineering department, AC Spark Plug Division of General Motors Corporation, Milwaukee, Wis., at the monthly meeting of that organization in the MSOE auditorium on May 4.

Mr. Becker explained the three main ways of modulating signals produced from desired data at a transmitter: frequency modulation, pulse duration modulation, and pulse code modulation.

He also gave a description of the types of frequency modulated receivers necessary to interpret and present the data in an intelligible manner.

Newly elected officers of the MSOE Student Branch were introduced at the meeting. They are: E. F. Zimmer, chairman; E. R. Miller, vice-chairman; R. H. Harter, secretary; A. L. Moore, treasurer; B. A. Butterfield and Dale Vogel, publicity. Their terms began in June and will run through December 1956.

Building Added to Illinois Institute of Technology

Illinois Institute of Technology (IIT), Chicago, Ill., has started work on a classroom and laboratory building that will

District No. 2 Prize Paper Competition

A GROUP OF COUNSELORS, students, and judges attending the District No. 2 Prize Paper Competition held at Carnegie Institute of Technology, April 27, and won by A. J. Pennington of Princeton University for his paper "Bats and Radar." Shown in the first row (*left to right*) are: J. M. Arthur, Duquesne Light Company, oral judge; E. R. Schatz, Carnegie Institute of Technology, written judge; C. T. Pearce, vice-president District No. 2; R. C. Gorham, counselor, University of Pittsburgh; H. S. Bueche, counselor, University of Delaware; and W. F. Denkhaus, Bell Telephone Company, oral judge.

J. A. ASCHOFF (*left*), Pacific Telephone and Telegraph Company, guest speaker at the luncheon meeting held at the U. S. Naval Postgraduate School, and Lt. C. A. K. McDonald (*right*), chairman of the Student Branch.

Official Photograph, U. S. Navy

become the home of its departments of electrical engineering and physics.

It will be the 21st new building at the 110-acre Technology Center, on Chicago's near south side, that Illinois Tech has been developing during the last 10 years.

The new structure, costing approximately $1 million, will provide 65,000 square feet of additional instruction space on three floors and basement, and is expected to be ready for use during the summer of 1957, according to President J. T. Rettaliata.

Designed by Ludwig Mies van der Rohe, director of the Institute's department of architecture, the building will match other modern campus structures in having an exposed steel skeleton and in being enclosed with plate glass above a low brick base.

The building will be located at the southeast intersection of Dearborn and 33rd Sts. and, in external appearance, will be a duplicate of the IIT chemistry building.

A half dozen large laboratories, a 300-seat auditorium, IIT's a-c network calculator, classrooms, and offices will be accommodated in the building which will be partially air-conditioned.

Providence Section Sponsors Annual Students Night

At the Annual Students Night sponsored by the Providence Section of AIEE, C. E. Nielsen, Jr., of Brown University was awarded first prize for his paper entitled "Kirchhoff's Laws and the Concept of Voltage as Applied to A-C Circuits," and A. L. Weiser of the University of Rhode Island was awarded second prize for his paper on "Magnetic Core Memory Device."

As is the custom for the Section, a meeting is planned once a year that will be of interest to engineering students in the area. This year the engineering department of the New England Telephone and Telegraph Company presented a talk and demonstration of direct distance dialing which is planned for the near future. This method makes it possible to dial across the country and to contact the other party in less than 15 seconds.

Two new affiliate student branches of the AIEE were welcomed at the meeting: the Bradford Durfee Technical Institute of Fall River, Mass., and the New Bedford (Mass.) Institute of Textiles and Technology. These two new branches have increased the membership by about 75 students.

Providence Journal-Bulletin Photo

AT THE PROVIDENCE SECTION Annual Students night were: (*left to right*) Paul St. Pierre, chairman Student Branch Activities Committee; A. L. Weiser, University of Rhode Island; C. E. Nielsen, Jr., Brown University; and Everett Adams, chairman Providence Section AIEE.

U. S. Naval Postgraduate School Holds Luncheon Meeting

The U. S. Naval Postgraduate School Student Chapter of the AIEE, in Monterey, Calif., held a luncheon meeting, Friday, May 18, at which J. A. Aschoff, of the Pacific Telephone and Telegraph Company, spoke on "Arctic Radar Network." Mr. Aschoff was engineer in charge of these radar installations, and presented an interesting account of some of the unusual problems encountered. His talk was illustrated with colored slides.

The student branch officers for the coming year were installed at this meeting. They are: Lt. C. A. K. McDonald, chairman; Lt. E. M. Baty, vice-chairman; Lt. R. A. Vollertsen, secretary; Lt. P. E. Trejo, treasurer; and Associate Professor C. B. Oler, counselor.

Student Paper Awards Presented by District No. 5

First prize in the Great Lakes District AIEE Student Paper Contest, held May 11–12, 1956, went to Roger Dolak of Iowa State College for his paper, "Effect of the Inversion Layer upon Radar." James Massey, University of Notre Dame, received second prize for "The Magnetic Monopole." Third prize was awarded to V. S. Levadi, Illinois Institute of Technology, for his paper, "Remote Tuning via Transmission Lines."

Honorable mention was given to two other students: E. K. Ranke, University of Detroit, "The Fundamental Physics of Nonlinear Dielectrics"; and F. R. Woldt, University of Wisconsin, "Principles of Ground-To-Air Missile Guidance Systems."

Advanced Study Grants Made By General Dynamics Corporation

Grants of aid for advanced study during the 1956 summer season have been awarded to five Rochester area teachers by General Dynamics Corporation, it was announced by L. C. Holmes (AM '31, F '51), director of research at the Stromberg-Carlson Division of General Dynamics Corporation, Rochester, N. Y., and chairman of the Stromberg-Carlson Scholarship Committee.

The teachers, each of whom will receive $400 to help defray the expenses of graduate study this summer, are: Miss Margaret Barry, and the Rev. F. C. Boehm, C.S.B., both of Rochester; Ingraham Humphrey, Canisteo, N. Y.; Mrs. Doris O'Dell, East Rochester; and Henry Salchak, Albion, N. Y.

The grants have been established by General Dynamics in recognition of the need for strengthening the teaching of science and mathematics in secondary schools.

OF CURRENT INTEREST

ELECTRONIC "NERVE" GAS DETECTOR, capable of instant detection of the deadly odorless, colorless chemical warfare agent was demonstrated with colored smoke by a special detachment of the Army Chemical Corps. The device, developed by RCA and the Chemical Corps, has been on the secret list until recently.

TALOS Guided Missile Air Defense Electronic Products Demonstrated

THREE MAJOR DEVELOPMENTS in the field of military electronics were demonstrated by the Radio Corporation of America (RCA) during recent dedication ceremonies marking an enlargement of the RCA Moorestown Engineering Plant for missile and surface radar electronic systems.

Dedication

The ceremonies, which included demonstrations and displays of some of RCA's latest developments in military electronics, were witnessed by military and Government representatives, and by more than 1,500 employees at the RCA plant.

General Sarnoff joined with Frank M. Folsom, president of RCA, and other executives to welcome Government, military, and other guests. Highlight of the ceremonies was the unveiling of a plaque which officially commemorates the RCA Moorestown plant as a missile and radar systems center and its abilities for engineering and producing complex electronic systems for national defense.

"During the past decade, developments in electronics have revolutionized the ancient art of warfare," declared General Sarnoff. "Foremost among these has been the development of the guided missile to a stage of perfection that makes it awesome in its capacity for destruction."

He stated that the German buzz-bombs which rained from the skies of Britain during World War II were as BB-gun pellets, compared to the modern guided missiles. Sobering, too, is the fact that the vast oceans and Arctic wastelands have been converted into highways for weapons which can destroy cities and their populations on a scale never before experienced by man.

The Soviet leaders Bulganin and Khrushchev openly boast of their "mighty guided missiles." The United States, thus, has no rational alternative but to meet the menacing competition whereby world communism has perverted science and technology to its evil purposes. For the sake of national security and the survival of civilization, the Kremlin must not gain even a temporary monopoly on such appalling weapons, it was pointed out by General Sarnoff.

By providing the Armed Forces with equipment vital to the success of their operations through the engineering and production of military equipment in an operating unit devoted exclusively to this mission, the RCA Defense Electronic Products unit and the organization at Moorestown is serving the nation.

Developments demonstrated were:

(1) A portable electronic detector for "nerve" gas—developed by the Army Chemical Corps and RCA. The first such detector accepted for military use, the unit not only can serve as a field alarm for military personnel and installations, but also can be utilized for gas-detection protection of population and industrial centers. It has possibilities as a detector for hazardous industrial and commercial gases.

(2) An RCA-developed wide-spaced image orthicon tube, or television camera tube, which can be used for televising scenes and objects under light conditions as low as those of a moderately cloudy moonlit night. Also described was the "Cat Eye" electronic light-intensifier, resulting from research of RCA in conjunction with the United States Air Force. This device is capable of viewing objects in almost total darkness to produce clearly defined television pictures.

(3) Noise-cancelling microphones and headsets for aircraft intercommunications systems, which RCA has developed and is producing for the U. S. Air Force. The highly selective and sensitive equipment provides clear communication under noise conditions which would make intelligible conversation virtually impossible by other known means.

The developments which were demonstrated, it was pointed out by T. A. Smith, vice-president and general manager, RCA

CLOSE-UP VIEW of electronic "nerve" gas detector which is an alarm device for field use. With the detector are (*left*) Lt. Col. O. R. Hertel Chemical Corps, Engineering Command, and T. A. Smith, vice-president and general manager, RCA Defense Electronic Products, Moorestown, N. J.

Defense Electronic Products, symbolized the many activities in broad and various fields of research and development carried forward by the RCA for the national defense program. A major supplier of electronic devices for the Government for more than three decades, and during the span of effort and experience RCA has developed the facilities and capabilities essential for meeting the increasing needs of the armed forces for equipment, ranging from basic radio devices to complex electronic systems on the scale of the land-based TALOS electronic control system.

Electronic "Nerve" Gas Detector

The electronic "nerve" gas detector was demonstrated by a special detachment of the Army Chemical Corps under the command of Lt. Col. O. R. Hertel, of the Chemical Corps, Engineering Command, Army Chemical Center, Md.

Colonel Hertel, who moderated the demonstration, told the audience that:

" 'Nerve' gas is the most deadly gas developed during or immediately after World War II, and is more than 1,000 times more effective than gas previously in use. Odorless, tasteless, colorless, and invisible, 'nerve' gas is so lethal and quick-acting that it will produce fatal spasms and convulsions within 45 seconds after contact or inhalation unless the proper antidote can be administered immediately.

"The gas attacks a chemical which operates between the nerves and muscles, causing almost instantaneous contraction and the beginning of destruction of the muscles and nerves. Early warning is vital to permit effective protective measures."

The RCA–Chemical Corps electronic detector which was demonstrated is a completely self-contained equipment for detecting the presence of "nerve" gas or G-agents in the air. A highly classified development until several months ago, the portable detector has been accepted by the Chemical Corps as a field alarm. It can be used also in a network to provide early warning for military, industrial, and population centers. The detector weighs only 24 pounds, and measures 15 inches high, 17 inches wide, and 7 inches deep.

In the demonstration, conducted on the grounds of the Moorestown plant, a soldier wearing protective clothing carried the detector into a cloud of harmless red smoke which had been discharged by grenades. Instantly the smoke enveloped the detector, the unit triggered a built-in audible alarm and a red warning light on its case. The soldier immediately signaled to a tactical team following to commence protective procedures. To dramatize the remote and broad warning which a single detector can provide, an audible warning on the plant's public address system and a large warning light which had been erected near the building were simultaneously activated.

In operation, air is sucked into the detector by a pump and filtered free from dust. Inside, a paper tape impregnated with a special colorless chemical solution is moved intermittently under the incoming air stream. Phototubes continuously scan the impregnated tape. G-agents in the air cause the tape to discolor. Instantly, the phototubes react to the change in reflected light caused by the discoloration and trigger the audible and visible alarms.

Wide-Spaced Television Image Orthicon Tube

The RCA-developed wide-spaced image orthicon tube demonstrated at Moorestown,

TELEVISION CAMERA TUBE operating in almost total darkness can transmit scenes that would be missed entirely by conventional camera tubes. The camera (*right*) is equipped with the new tube—known as a wide-spaced image orthicon—(*left*) a monitor shows the pickup, with the face of the subject clearly identifiable.

Mr. Smith explained, is basically a standard television camera pickup tube, with innovations that increase its sensitivity from five to ten times. The wide-spaced image orthicon tube plugs into a standard television camera. Designed to provide television picture with good resolution and clarity under low light conditions, the wide-spaced image orthicon tube will televise objects under light conditions of a cloudy, moonlit night.

The developmental tube gives promise of numerous military and commercial applications, for televising images under low light conditions, and is being used experimentally by the military services.

During demonstrations, a television camera with a wide-spaced image orthicon tube was focused on a model seated in a lighted room. The camera was turned on and the room lights switched off, rendering the model virtually invisible to the military and press visitors in the room. The image-orthicon tube, however, projected a bright, clear image of the model to a television receiver in the room.

"Cat Eye" Light Intensifier

Described, but not demonstrated there, was the "Cat Eye," an electronic light intensifier which is capable of seeing objects in the dark to produce sharp and clear television pictures.

The U. S. Air Force has already announced that the "Cat Eye" enables airmen to see in the dark with almost daylight clarity, and that it is expected to become a valuable aid to the Air Force as a reconnaissance device.

During a demonstration of the electronic light intensifier several weeks ago at the Air Force's Wright Air Development Center (WADC), Dayton, Ohio, Dr. Lee Devot, chief, Physics Branch, Aeronautical Research Laboratory, emphasized that the experimental system represents a major step beyond any previous light-intensifying techniques, excelling the human eye in sensitivity. At the Dayton demonstration, the light intensifier was focused on a rotating globe in a room which was completely dark so far as the human eye could determine. Although the viewers were unable to see the globe itself in the darkness, a bright, high-contrast image of the globe was produced on an adjacent television viewing screen.

The electronic light intensifier was developed under Air Force contract at the David Sarnoff Research Center of RCA, Princeton, N. J., by Drs. G. A. Morton and J. E. Ruedy. Research on the project at the WADC was conducted by R. K. H. Gebel.

Operating on television-like principles, the light intensifier senses and amplifies the always present photons unseen by the human eye. Photons are bundles of electromagnetic waves which, in sufficient numbers, appear to the eye as light.

Noise-Cancelling Microphones and Headsets

A third major demonstration centered about noise-cancelling microphones and headsets—essential elements of a high-intelligibility interphone system for airborne intercommunication, which RCA is now producing for the U. S. Air Force.

The development in recent years of more powerful airplane engines, particularly turbo-jet types, it was explained, raised in-plane noise to levels beyond the capabilities of conventional airborne intercommunications equipment to provide intelligible conversations. The problem was complicated further by the increasing reliance on single code words for whole messages, making crystal-clear communication among crew members imperative.

Under a highly classified contract with the U. S. Air Force, RCA undertook successfully the development of noise-cancelling intercommunication microphones and headsets which at noise levels as high as 120 db provide communication as clear as person-to-person conversation under ideal condi-

tions. At 120 db, a speaker is unable to hear himself talk.

The new RCA equipment developments, now declassified, have been used by the Air Force for several years, and provide more than 25 per cent greater intelligibility at jet-engine noise levels than equipment previously available.

During these demonstrations, military and press guests were ushered into a room in which in-plane noise of approximately 115 to 120 db was simulated. Conversation was an impossibility. Upon donning the RCA noise-cancelling microphones and headsets, the guests were able to converse clearly without interference ambient room noise.

This demonstration featured hand-free microphones—a combination headset with an adjustable boom microphone which can be fixed directly in front of the lips. The noise-cancelling principles also have been adapted for hand-held microphones and oxygen mask microphones.

The microphones in each type are pressure-gradient moving-coil types designed to discriminate between sounds originating from distant and immediate sources. The discrimination is accomplished, in part, by exposing both sides of the microphone diagram to the sound field. Sound from a source close to the microphone—the lips—applies greater pressure to one side of the diaphragm than sound—such as ambient in-plane noise—from a distant source, and the microphone responds to the difference in pressure. In effect, the microphone cancels out extraneous noise, and permits transmission of the sound issuing from the speaker's lips.

Among the more important innovations of the new equipment are operation over the full frequency range of 200 to 6,100 cycles, contributing to the equipment's high word intelligibility, and a constant level of operations under unpressurized conditions, up to 40,000 feet.

Jet Engine Testing Computer Developed for ARDC

A GIANT computing machine that could save up to two years in the costly development of advanced-design jet engines has been built for the Air Research and Development Command (ARDC) by the General Electric (GE) Company, Schenectady, N. Y.

One of the largest ever built, this unique analogue computer will enable engineers to "fly" jet engines before they are built and to forecast, in actual control tests, performance characteristics of jet engines that are still on the drawing boards.

The computer will become the "brain" for a jet engine simulator that will reduce costly wind-tunnel testing and cut down the time and cost of flight-testing, both vital phases in the race to develop stronger and faster aircraft.

The jet engine simulator was developed and is being built by GE's Aircraft Gas Turbine Development department under an ARDC contract. The computer for the simulator was designed and built by the company's General Engineering Laboratory.

"Flying" the computer, an engineer can become a "test pilot" and in a matter of a few hours can see how his blueprint engine reacts to such conditions as giving it the throttle at 20,000 feet altitude, 40 degrees below zero air temperature, and at a speed of 1,260 miles an hour.

Previously, it has not been possible to check out a preproduction engine control system on a sufficiently large number of engines of one type. In many instances, the engine is either not available and its expected performance data is lacking, or, if an experimental prototype of the engine is available, engineers have been unwilling to risk the expensive prototype in gruelling tests.

Checking out an experimental engine normally takes up to six months and costs several million dollars in the wind-tunnel and flight-test phases.

The machine works this way:

Engineers study the specific problem at hand and reduce it to mathematical form. They then convert it into equations. The computer works out these equations electroni-

Official Air Force Photo

MILLION-DOLLAR BABY FOR FUTURE JETS. Engineers check out a complex jet engine problem on one of the world's largest analogue computers—the jet engine simulator. The machine enables engineers to "fly" jet engines before they are built, thus saving millions of dollars and up to two years in testing and control design.

Future Meetings of Other Societies

Western Summer Radio-Television and Appliance Market, July 16–20, Western Merchandise Mart, San Francisco, Calif.

Scientific and Technical Writing Conference, August 20–24, University of Pennsylvania Institute for Co-operative Research, Philadelphia, Pa.

Western Electronic Show and Convention, August 21–24, Pan Pacific Auditorium, Los Angeles, Calif.

ASCE, National Hydraulics Division Annual Meeting, August 22–24, University of Wisconsin, Madison, Wis.

National Council of State Boards of Engineering Examiners, 35th Annual Meeting, August 23–25, Hotel Statler, Los Angeles, Calif.

Association for Computing Machinery, Annual Meeting, August 27–29, Westwood Campus Los Angeles, Calif.

National Metal Trades Association, September 9–12, Essex-Sussex Hotel, Spring Lake, N. J.

Information Theory Symposium. September 10–12, Massachusetts Institute of Technology, Cambridge, Mass.

Titanium Lecture Program, 2nd Annual Series, September 10–14, New York University College of Engineering, University Heights Campus, The Bronx, N. Y.

ASME, Fall Meeting, September 10–12, Cosmopolitan Hotel, Denver, Colo.

RETMA, Symposium on Reliability of Electrical Connection, September 11–12, University of Pennsylvania, Philadelphia, Pa.

Transport Phenomena in Metals, September 10–14, International Union of Pure and Applied Physics, National Research Council, Ottawa, Ont., Canada.

2nd Conference on Reliable Electrical Connections, RETMA, September 11–12, Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa.

ASTM, 2nd Pacific Area National Meeting and Apparatus Exhibit, September 16–22, Hotel Statler, Los Angeles, Calif.

Instrument Society of America, Conference and Exhibit, September 17–21, New York, N. Y.

American Transit Association, Annual Meeting, September 17–20, Jefferson Hotel, St. Louis, Mo.

Illuminating Engineering Society, National Technical Conference, September 17–21, Hotel Statler, Boston, Mass.

11th Annual International Instrument-Automation Conference and Exhibit, September 17–21, Coliseum, New York, N. Y.

PGNS-IRE, Annual Meeting, September 20–21, Mellon Institute Auditorium, Pittsburgh, Pa.

National Electrical Contractors Association, Annual Convention and 2nd Exposition, Sheraton-Palace Hotel, San Francisco, Calif.

Atomic Industrial Forum, 1956 Trade Fair, September 24–28, Navy Pier, Chicago, Ill.

Audio Engineering Society, Annual Meeting and New York High-Fidelity Show, September 26–30, New York Trade Show Building, New York, N. Y.

National Electronics Conference and Exhibit, October 1–3, Hotel Sherman, Chicago, Ill.

Heating, Piping, and Air-Conditioning Contractors National Association, The Mechanical Contractors Association of America, Fall Meeting and Conference, October 1–3, Hotel Statler, Detroit, Mich.

American Mining Congress, Metal Mining Industrial Minerals Convention and Exposition, Shrine Exposition Hall, Los Angeles, Calif.

Porcelain Enamel Meeting, ASTM Committee C-22, October 2–3, Battelle Memorial Institute, Columbus, Ohio.

Standards Engineers Society, 5th Annual Meeting, October 3–5, Willard Hotel, Washington, D. C.

International Association of Electrical Leagues, 1956 Conference, October 3–6, Sheraton-Cadillac Hotel, Detroit, Mich.

SMPTE, 80th Convention, Exhibits, October 7–12, Ambassador Hotel, Los Angeles, Calif.

International Science and Human Welfare Conference, American Institute of Geonomy and Natural Resources, Inc., October 8, Washington, D. C.

Civil and Military Aeronautical Communications, 2nd Annual Symposium, Rome Air Development Center Griffiss A.F.B., October 8–9, Utica, N. Y.

cally and comes up with the answer in the time it takes an air molecule to pass through an actual engine.

The GE computer, which took six years to build, measures 35 by 100 feet and is 12 feet high. It covers a floor area of 2,635 feet, roughly the equivalent of three average-sized homes, and uses 40 tons of air conditioning, equivalent to air conditioning 15 average-sized homes or 80 room air conditioners.

The vast amount of air conditioning is necessary to insure the accuracy of instruments and the efficiency of vacuum tubes, which are sensitive to abrupt temperature changes.

Its power source operates on 2,300 volts rms. Its 150-hp motor and four generators can develop 103 kw, enough to run 30 to 50 average electric kitchen ranges with all burners and ovens lit.

The computer units contain 6,000 vacuum tubes, 140,000 feet of wire and 1,700 indicating lights. It has 2,750 knobs or dials, 8,200 plug jacks, 300,000 soldered joints, and 100,000 solderless connectors.

An estimated 85,310 man-hours went into the finished product, roughly equivalent to 42 man-years of work. Approximately 8,350 hours ($2^1/_2$ man-years) were spent in the drafting stage, approximately 44,960 man-hours in engineering (23 man-years), and about 32,000 man-hours (16.3 man-years) in manufacturing and assembly.

Nuclear Power Plant Visited by Sir Edwin Plowden

WITHIN THE TERMS of the United Kingdom–United States of America Agreement for Co-operation in Peaceful Uses of Atomic Energy, Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority, was the guest of Lewis Strauss, chairman of the United States Atomic Energy Commission, on a visit to the Argonne National Laboratory near Chicago, Ill.

The two chairmen visited the Laboratory and other United States atomic energy installations which were arranged according to the terms of agreement between the two countries.

The Atomic Energy Commission's Chicago Operations Office planned the tour of the Laboratory where a 5,000-kw nuclear power plant is in the process of being constructed. The power plant is being built within a huge steel shell.

Accompanying Mr. Strauss and Sir Edwin were Dr. W. H. Zinn, director of Argonne National Laboratory; J. J. Flaherty, manager of the Commission's Chicago Operations Office; Adm. Francis Old, U.S.N. (Ret.), who is now with the Sumner Sollitt Company which is the construction contractor of the installation; and A. Tammaro, assistant general manager for Research and Industrial Development of the United States Atomic Energy Commission.

The group of officials toured the entire installation. They stopped to examine the various items of research equipment used in connection with Argonne National Laboratory's *CP-5* nuclear research reactor.

Argonne National Laboratory photo

VISITORS to the Argonne National Laboratory near Chicago, Ill., with Dr. W. H. Zinn (*left*), director, Argonne National Laboratory, are Sir Edwin Plowden (*center*), chairman, United Kingdom Atomic Energy Authority; and Lewis L. Strauss (*right*), chairman, United States Atomic Energy Commission.

New-Look Fluorescent Lamp Gives Double the Light Output

A new fluorescent lamp with double the light output of present tubes of equal length has been developed recently.

The increased light is made possible by a revolutionary change in tube design featuring a series of lengthwise dents or grooves along one side of the eight-foot-long fluorescent tube. Because of its high light output and unique appearance, the new lamp has been named "Power-Groove" by the General Electric Company (GE).

At the grooves, the new tube is nearly U-shaped in cross-section. This design permits a maximum circumference of the tube while constricting its inside area and provides about 12 per cent more light output above and below the grooves.

The greater light output results from an increase in area of the lighted tube surface, the higher wattage at which the new tube can be operated, and the more effective use of energy within the tube.

The development breaks through a stubborn barrier which has restricted the amount of light obtainable from fluorescent sources. It achieves its huge gain in light output with no loss in efficiency, or units of light produced per watt consumed.

By doubling the light output of fluorescent lamps, GE has achieved a greater gain in light per foot than had been achieved by all similar improvements combined since fluorescent lamps were introduced 18 years ago. The Power-Groove produces five times as much light per foot as the original fluorescent lamp and a 10 per cent saving in over-all cost.

In the past, all popular fluorescent lamps have been tubular sources of light of varying diameters and lengths. The new development incorporates a series of lengthwise grooves along one side of the lamp, increasing greatly the permissible wattage input and light output of a given length of lamp.

GE Press Relations photo

TWICE THE LIGHT is shown by meter reading. The four and eight foot General Electric Power-Groove fluorescent lamp produces twice the light of existing fluorescent lamps with no loss in efficiency. Eugene Lemmers, Large Lamp product engineer at Nela Park, Cleveland, O., makes test.

The scientific principle involved is to diminish the internal loss of energy before it can be turned into visible light. The loss is caused largely by absorption in the mercury vapor within the lamp. The grooves constrict the area within the bulb, and since the radiation has less distance to travel, more of it survives to activate the phosphor.

The relatively new "rapid start" principle is being used in these lamps so that they will be essentially instant starting and have ballast equipment of minimum size and cost.

GE engineers have had to design new ballasts for the Power-Groove, and new fixtures will have to be designed to accommodate the new lamp. It will be used in new installations, and not for replacements in existing fixtures.

The Power-Groove will have its first applications in commercial and industrial areas, and is expected to extend the use of fluorescent lighting into areas which heretofore have used incandescent and mercury sources. Installations will include lighting in factories, stores, schools, offices, outdoor, and other areas.

Basic length of the Power-Groove will be eight feet, but four-foot lamps will be available to fill in where necessary. A six-foot Power-Groove probably will be developed for street lighting. The lamp is two and one-eighth inches in diameter and is rated at at about 200 watts.

Highway Safety Is Human Engineering Problem

The bloodiest year on our nation's highways was 1955, with a near record total of 37,800 deaths. As if this were not grim enough, our young drivers figured prominently in compiling these statistics. More than 27 per cent of all drivers involved in fatal accidents last year were under 25 years of age, a greater number than ever before.

This figure, in the recently released safety booklet "Fatal Fallacies," an annual publication of the Safety Service of The Travelers Insurance Companies of Hartford, Conn., emphasizes the fact that the safety record of drivers under 25 deteriorated sharply in 1955. The inescapable conclusion to this is that excessive speed and recklessness are the principal faults in these accidents.

In comparison, it can be pointed out that the group of drivers over 25 years of age made a significant improvement in their safety record for 1955. This improvement was evident particularly in the incidence of fatal accidents, once again pointing to the speed and recklessness of younger drivers.

Young people react quickly and learn quickly. With these two factors in their favor, their driving record should, theoretically, be better than that of their elders. Fast reflexes are not enough, however, to avert a serious accident involving a recklessly driven car traveling at an excessive rate of speed. The capacity for rapid learning must be utilized as well, in increased driver training programs, particularly in high schools.

Speed and recklessness should be the primary targets of these programs.

In 1955, more than 15,000 individuals did not return home after the pleasures of the weekend. These Americans were killed in weekend traffic accidents. Of last year's traffic fatalities, more than one fifth occurred on Saturday.

The reasons for this record number of weekend highway fatalities lie in the motoring habits of the American public. Every highway in the nation has its Saturday share of that portion of Americans bound and determined to arrive at its weekend destination in time for dinner, even if the trip's last 60 miles must be covered in an hour flat. Too frequently, the strain and fatigue of distance driving are ignored in anticipation of ample relaxation at the journey's end.

Then, too, our highways continue to be filled with those drivers whose idea of relaxation is an extra drink or two "for the road."

Millions of dollars have been spent by Federal, state, and municipal authorities in an effort to provide better and safer roads. Additional millions are spent by insurance companies and other private organizations for safety education programs.

Nevertheless, the weekends of 1955 saw more persons killed and injured on our highways than ever before. It wasn't the fault of the road systems; it wasn't the fault of safety education campaigns. It was the fault of pleasure-bent individuals striving to go too far, too fast, for a weekend's fun.

How can we reduce this record total of killed and injured? What is desperately required is the immediate, unceasing cooperation of every American in possession of a driver's permit.

An aroused awareness of the weekend highway peril, plus continued realization of this danger is the only way to reduce the weekend fatality figures for 1956.

Air Traffic Control System Ready for Evaluation

The first Volscan air traffic control system has been assembled and is ready for delivery to the Air Force for flight evaluation. Volscan is a large analogue computer and forms a link between traffic control radar and existing GCA (ground control approach) or ILS (instrument landing systems). It has been termed the most effective existing solution to the mounting problem of air traffic control and is capable of bringing aircraft to the final approach entry point at the rate of 120 planes per hour. Volscan, a development of the Crosley Government Products Division of Avco Manufacturing Corporation, can nearly triple the effective capacity of an airport.

Volscan was conceived and an advanced development model was fabricated and flight tested by the Cambridge (Massachusetts) Research Center, U. S. Air Force. The Crosley Division obtained a contract for the design and manufacture of three Volscan systems, and the one now ready for final evaluation tests is a production prototype.

Practical application of the unit at some of the nation's largest airports will be investigated by commercial airlines because it promises to minimize "stacking up" of heavy traffic and reduce flight cancellations. Recent statistics show that as many as one third of all flight cancellations are due to congestion on important routes.

Unlike other systems still in the planning stage, Volscan does not require any special equipment aboard the aircraft. Any plane equipped with two-way radio can use it. A complete Volscan system includes 26 units. Three of the units are consoles for operators and are about the size and shape of a playing unit for a large theatrical organ. The other 23 are large cabinets, each of them about four times the size of a clothes locker. All of the units are filled with complicated electronic circuitry. There is approximately 100 miles of wire in a Volscan system.

When an aircraft comes within the radar scope of an airport its "blip" appears on a radar screen in front of an operator. Its location is plotted with a light gun and instantly the Volscan computers go to work. They have stored up within them the answers to every possible approach problem and in a fraction of a second, they assign a "cube in space" to the arriving aircraft. This "cube in space" is given to the pilot of the arriving aircraft by radio advising him to proceed at the proper heading, altitude, and air speed. The Volscan computer does this by projecting a course of flight which will delay or speed up the aircraft so that its arrival time at the "entry gate," both in approach and arrival, is efficiently and safely its own. The "entry gate" is a position in space some 1,000 feet from the ground and 2 miles from the touchdown point at the end of the runway. The GCA or ILS systems take the aircraft through its final approach to the runway.

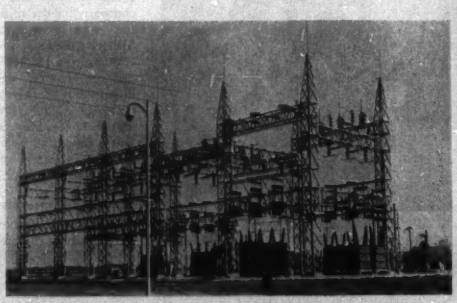
Rock River Station Depends on Battery Power

Large amounts of alternating current at high voltage are controlled both normally and in emergencies by direct current supplied by a 250 volt storage battery at the new Rock River Generating Station of the Wisconsin Power and Light Company near Beloit, Wis.

Many innovations are incorporated in its two 75,000-kw units and auxiliary equipment. Distribution is made to the system at 138,000 volts. The 120-cell Gould Planté battery plays an important part in the operation of the plant and the distribution of the electrical energy.

Power from the battery opens and closes switches that control the transmission of current through the plant transformers. Small motors throughout the station regulate flow of air into the boilers and flow of steam into the turbines. In addition, the battery supplies power for emergency lighting of the plant and emergency operation of the hydrogen seal oil pumps on the turbines.

The battery is kept charged by a small motor-generator set which is powered by alternating current from the plant.



BATTERY operates switches that control transmission of power through this transformer station at 138,000 volts.

Rugged High-Speed Camera Is Adaptable

A high-speed "motion analysis" camera (MAC), capable of taking high-quality pictures within range of 5,000 per second and incorporating the most advanced features of high-speed photography, has been designed by the Fairchild Camera and Instrument Corporation, Syosset, N. Y.

This 16-mm camera, utilizing rotating prisms, can be adapted to many variations. An industrial model is planned, which is capable of taking as many as 5,000 pictures per second; an airborne model has been designed, which has a maximum picture taking rate of 2,000 per second; and a missile hit-miss model, already proved able to take 250 pictures per second, is being engineered to take as many as 1,000 pictures per second. Both the industrial and airborne models have film capacities of 100 and 200 feet, using daylight loading spools.

The rotating prism has been selected for the highest possible index of refraction and lowest dispersion with a minimum thickness and minimum angle of incidence. The result is an evenly illuminated picture that has a sharp frame line, with no overlapping of images of one frame into the next.

The camera is both lightweight and compact. To give particular speed ranges, a family of interchangeable 28-volt d-c motors are used to drive the several models of the MAC. The motors can furnish maximum acceleration in a minimum time, and the camera has sufficient power to start at high speed.

According to the designer, J. H. Waddell, Fairchild authority on high-speed cameras, one of the most advantageous features of the camera is its ruggedness. A minimum of maintenance is required. The housings are heat-treated cast-aluminum alloy and so designed to take high g shock. It is built to operate at 55 g constant acceleration, 10 g vibration at or through a range of 10 to 500 cycles in one second, at temperatures from −65 F to +200 F, 100 g shock.

In the first of two studies, a MAC was mounted on the floor of a rocket-propelled sled. Deceleration forces were in excess of 60 g when the sled was travelling at 600 mph. Vibration of the sled floor far exceeded laboratory test conditions. Timed to study the ejection of a pilot's seat, the camera at the rate of 800 pictures per second clearly recorded the functioning of the ejection as it occurred. Subsequently, a second study was made on a sled travelling at supersonic speeds. The camera, again riding on the floor of the sled, operated successfully during an initial acceleration of 200 g, which finally settled down to 50 g.

THIS RUGGED high-speed "motion analysis" camera, designed by the Fairchild Camera and Instrument Corporation, Syosset, N. Y., is capable of taking 5,000 pictures per second.

Air-to-Air Guided Missile Guards Fleet and U.S. Coasts

The U. S. Navy and Department of Defense have announced that supersonic air-to-air guided missiles now guard fleet units and the U. S. coasts. The missiles, designated SPARROW I, have reached a combat-ready status which has been confirmed by Admiral Arleigh Burke, chief of Naval Operations.

The deadly accuracy of the SPARROW I system has been demonstrated by hundreds of missile launchings against drone targets. Successful attacks have been completed against high-speed jet aircraft and against other missiles.

Numbers of target drones have been blasted out of the sky with the lethal warhead carried by the missile.

It is stated that these defensive weapons are a powerful deterrent against attack by high-speed jet bombers and fighters. Operational squadrons have been assigned to carriers. Additional carriers of both Atlantic and Pacific fleets, including the supercarrier *USS Forrestal*, will be equipped with squadrons of aircraft armed with the SPARROW I missiles as the ships are deployed overseas.

The SPARROW I is versatile and permits effective attacks against all types of aircraft, at all operational altitudes. Pilots have been trained to operate the Chance Vought *F7U-3M* "Cutlass" jet interceptor armed with the SPARROW I, from both carrier and shore bases.

For present readiness of the fleet with an air-to-air missile system, Assistant Secretary of the Navy (Air), J. H. Smith, credits years of intensive development by the Navy's Bureau of Aeronautics and Naval Air Missile Test Center, and the Sperry Gyroscope Company.

The Navy also announced current contracts of more than $50 million with the company for the missile guidance radars and test equipment, and for production of SPARROW I missiles at the Sperry Farragut Company in Bristol, Tenn.

Some general details of this air-to-air missile also were released for the first time officially. The SPARROW I is approximately 12-feet long, weighs about 300 pounds and is propelled by a solid rocket motor to a velocity in excess of 1,500 miles per hour within seconds after launching. Launching of missiles may be either singly or in rapid succession. Missile wings deflect in response to guidance signals to direct the SPARROW I to intercept the target, even under evasive action.

Successful attacks have been completed with the weapon against high-speed jet aircraft and also against other missiles. Versatility of the weapons system permits effective attacks against high- and low-altitude targets flying either singly or in groups.

Besides the carrier-based SPARROW I Cutlass system in fleet use, the Sperry SPARROW I weapon system also is now in operational use with a night fighter squadron of the U. S. Marines employing the two-place Douglas *F3D-2M* Skynight.

Cold Air Heats Buildings with New Compressor System

The first practical system of heating a building without fuel by using below freezing outside air as a heat source was announced recently by the York Corporation, York, Pa. The heat-pump system is the same refrigeration system used to cool the building during the hot summer months.

This announcement climaxes a 104-year search for an economical and practical heat pump. First conceived by the British scientist Lord William Thomson Kelvin in 1852, the heat pump has been the subject of many millions of dollars of research in the intervening years. Although a number of leading companies have developed various types of heat pumps in the past few decades, no one previously has been able to create a heat pump that could operate economically using outside air at temperatures much below freezing. With outdoor temperatures colder than this, expensive supplementary electric resistance heating had to be used to warm the building. This fact relegated practical use of the air source heat pump to the more temperate climates.

The heat-pump system automatically heats or cools the rooms in a building, depending on the climatic conditions, and always provides the desired room temperature. Thermostatically controlled valves guide the hot or cold water flow in and out of the system, while the compressors automatically move from single-stage compression into compound compression when temperature drops below a certain point.

Using only the electricity needed to run the compressors, which form an integral part of the basic refrigeration unit, the heat pump can remove heat from cold outside air, while cooling this air to still lower temperatures as it passes over specially designed coils. The heat removed by the refrigerant from the outside air is elevated to a usable temperature level by the compression cycle. This heat can be used to produce hot water, which can be circulated throughout the building in an indirect system, or the hot refrigerant can be used directly in coils to provide forced warm-air heating through either a central unit or multiple units.

During warm weather, conversely, the expansion or cooling of the refrigerant, as it turns from liquid to gas, extracts heat from the water circulated through the refrigerant. The resulting chilled water is piped to the same coils and cools air blown through these coils.

Two new buildings presently are using, or being equipped with, the new York heat-pump system. The company's research and engineering departments are currently working on the miniaturization of the system into packaged units to make home use of the heat pump practical at some future date.

Stratospheric Television for Jet Aircraft Reconnaissance

Television moved into the supersonic age with the announcement that Philco Corporation has developed an airborne television system which may be used in jet aircraft reconnaissance by the U. S. Air Force.

Developed at Philco's Government and Industrial Division for the Aerial Reconnaissance Laboratory at Wright Air Development Center (WADC), the new airborne television system will provide ground control points with an active picture of troop movements or terrain. It now is possible to transmit a television picture, not only from near ground level, but from the stratosphere, beyond reach of antiaircraft gun fire. The scope of such a reconnaissance system is almost unlimited.

Unlike those systems which have been used commercially to relay television signals from one ground point to another, via a slow-circling plane, the new airborne reconnaissance system is a complete, self-contained, broadcasting station. It is so compact that it may be carried in single-seat aircraft. Philco has many years of research and development experience on this type of equipment.

To cover a wide area, two unmanned, studio-quality television cameras are used in the plane. Signals from the plane are transmitted to the ground control point where they are picked up by a receiver. There, the picture may be instantaneously photographed on 35-mm film which can be processed in less than a minute. Immediately, the picture may be projected on theater-size screens at the control point, or relayed to other locations. Also, pickups from slower-moving aircraft may be observed, live, on standard fine-line monitors.

Philco has overcome the inherent difficulties of obtaining a clear, sharp picture from aircraft traveling at supersonic speeds by the development of unique transmitter circuitry and the method of transmitting a high-quality picture. The picture obtained is as good as, or better than, commercial television reception. It is now possible to slow, or stop, television pictures taken at high speeds without a blur of ground movement.

Data, such as time and position, may be automatically printed on the film. In addition to on-the-spot coverage, a permanent reconnaissance record may now be maintained.

ONE MAN EXERCISES easy control of thick steel plate as new design power-rotated jib crane lifts load, swings boom, travels trolley, and is ready to "spot" load at precise point desired. LeTourneau high-torque motor (inset) is geared between crane pillar and rotating mechanism. Most unique feature of new crane, besides its high-capacity handling ability, is fraction-of-an-inch control which single operator maintains over load at all times.

Fraction-of-an-Inch Control Operates Jib Crane

Industry's first power-rotated jib crane with lifting capacities up to 15 tons has just been introduced after several years of development and extensive on-the-job testing by R. G. LeTourneau, Inc., Longview, Tex.

Available in capacities of 6, 7½, 10, and 15 tons, each crane has a 25-foot boom which, when rotated in a full circle, covers 1,965 square feet of floor space. The electric rotating mechanism, as well as electrically powered hoist and hoist trolley which are available, all are built to provide extreme precision and fraction-of-an-inch control not previously available to industry. This "inching control" is incorporated into all phases of the design for smooth handling and exact spotting.

Many applications are developing for the new ultraheavy-duty units, particularly where one-man handling is required of such items as castings, cargo crates, ingots, machine tools, pattern molds, power units, steel slabs, and other loads within the 30,000-pound class. The new cranes often can be used to avoid expensive tie-ups of overhead cranes, and their all-weather design makes them ideal for outdoor as well as indoor work.

Heavy-duty electromechanical motor brakes, plus built-in regenerative electric braking action, provide absolute control of both boom and load.

All controls for both the jib crane and the hoist selected are of simple push-button design, conveniently suspended together from the hoist to permit handling by a single operator.

Compact Air Force Computer Features Ferractors in Its Core

Two revolutionary developments in high-speed, general purpose electronic computer construction were revealed in a demonstration of the new, compact Remington Rand Univac *AF/CRC* magnetic computer, designed and built for the Air Force Cambridge Research Center at Lawrence G. Hanscom Field, Bedford, Mass.

The new computer will be assigned to classified military projects according to Air Force officers, who sponsored its construction, but its new principles of operation make it highly efficient in the solving of all types of complex mathematical and scientific problems.

As versatile as the giant electronic "brains," the latest in the Univac family can be housed in about 250 square feet. Its computer unit is only 6 feet high, 6½ feet long, and 18 inches deep. Its desk-sized console, housing the operator controls, the paper tape, input-output unit, and the direct entry typewriter, is only 4½ feet high 6 feet long, and 3 feet deep.

The Univac *AF/CRC* employs tiny pulse-amplifying devices known as "ferractors" in its internal magnetic-core circuitry and a 5- by 3-inch magnetic drum, spun at 16,500 rpm, to accomplish this remarkable reduction in size without sacrifice of speed or capacity.

The ferractors represent a 5-year pioneering search by scientists of the Remington Rand Univac Division of the Sperry Rand Corporation for an efficient, reliable substitute for the space consuming vacuum tubes of earlier computers. Their basic make-up is simple, although production requires the painstaking skill of watchmaking, with much of the work under special lighting and heavy magnification.

The ferractor itself is primarily a minute ring of metal, roughly spool-shaped. Another strip of metal is set around the outer circumference, something like an iron tire on a wagon wheel. The whole thing is wrapped round and round radially with fine, insulated wire.

About 40 of these spools would just about fill a jumbo peanut shell. The smallest vacuum tube in a radio set could easily hold dozens of them. The "wagon tire" strip is the thinnest metal ever rolled in the history of metalworking. Gold-leaf, the only thinner metal in existence, is beaten thin, not rolled.

Ordinary coil-winding devices generally in use are far too clumsy and coarse for the

job of wrapping the thread-like insulated wire around the rim of the basic assembly. Special machinery had to be devised for the job.

Two ferractors, each replacing an old style vacuum tube, are sealed within a casing like a miniature pill box, about 5/8 inch in diameter and slightly less than 1/4 inch thick. Four "pill boxes" are mounted on thin plastic cards, each about the size of a postcard, along with a number of resistors and a line of midget diodes, tiny electronic fittings.

The cards fit into the front of the computer, set edgewise. Each card, or package, makes contact with many fixed points at the back, actually tiny wires with fitted ends resembling a telephone operator's cord plugs, except that they are less than 1/2 inch long. Each plug fits into a "jack" just tightly enough to stay put. About 600 such cards, plus a few ordinary transistors, form the main working portion of the computer along with the high-speed magnetic drum.

The magnetic drum memory of the *AF/CRC* was also specially developed by Remington Rand engineers to meet the high-speed and low-power requirements of the new computer.

The drum consists of a cylinder, 5 inches in diameter and 3 inches in length, spun by a small motor at 16,500 rpm. Its bearings are ground to a mirror finish within 0.0001 inch.

The composition of the nickel-cobalt alloy coating the cylinder's outer surface is a discovery of Remington Rand metallurgists. The drum receives and retains myriads of magnetic impulses imprinted by "writing heads," set 0.001 inch off the nickel-cobalt coating.

These "heads" have the appearance of mere flat bits of metal, about 3 inches long, 1 inch wide, and 1/2 inch thick. Actually, each is an unbelievably intricate laminated assembly containing as many as 34 tiny L-shaped metal components, each carefully wound with wire thinner than a toothbrush bristle.

The whole drum is sealed in a box-like metal casing about 1 cubic foot in size and filled with helium. The helium "atmosphere" is to lessen frictional resistance to the high speed with which the drum revolves and accordingly produces far less heat. In addition, helium "transfers," or passes on, any heat developed at a far greater speed than ordinary air, allowing the drum to run considerably cooler. Any significant uncontrolled heating would cause the drum ultimately to expand enough to result in actual contact with the head.

The computer unit, itself, contains a pair of electric exhaust fans to insure cool operation as a protection to heat-sensitive units and circuits anywhere in the machine.

In electronic engineering terms, Univac *AF/CRC* uses a "parallel bit serial digit code at a 660 kilocycle per second bit rate, which allows the addition of two 10-digit numbers in 90 microseconds, over 11,000 additions per second, and multiplication in from 0.3 to 1.7 milliseconds, over 3,000 multiplications per second."

Its use of paper tape makes the new computer compatible with all common-language processing, instrumentation, or data-presentation systems.

Earth Satellite Developments Detailed

The U. S. Navy, The Glenn L. Martin Company of Baltimore, Md., and the Minneapolis-Honeywell Regulator Company disclosed that Project Vanguard is the name which has been assigned to the program for a man-made instrumented satellite to be launched during the International Geophysical Year (IGY) as part of the United States scientific program. The Martin Company is the prime contractor for the launching vehicle, a three-stage rocket, that will attempt to place the world's first man-made earth satellite in its orbit. The St. Louis, Mo. electrical manufacturing firm, Vickers Electric Division, Vickers Incorporated, a unit of Sperry Rand Corporation, has been selected to design and manufacture the magnetic amplifier autopilot unit.

A reference guidance system to help guide Project Vanguard towards upper atmosphere will be designed and manufactured by the Aeronautical Division of the Minneapolis-Honeywell Regulator Company.

The magnetic amplifier autopilot unit to be designed and manufactured by Vickers will control the flight of the Vanguard vehicle from its launching point on Florida's east coast to an altitude of approximately 300 miles above the earth.

The magnetic amplifier autopilot unit will take its flight instructions from the gyro reference system. It will operate as necessary to keep the Vanguard vehicle on its predetermined flight course by moving the rocket engine, mounted on a gimbal—a kind of universal joint—so that the thrust of the engine will push the entire vehicle in the desired direction.

The reference system will sense changes from the rocket's desired trajectory. Information necessary to make corrections will be relayed through an autopilot to the servo motors of the Vanguard vehicle. Corrective movement transmitted by servos to the rocket engine, mounted on the gimbal will keep Vanguard on its course.

"Brain" of the guidance system will be three HIG (Hermetic Integrating) gyros to sense roll, pitch, and yaw, combined with other components manufactured by Honeywell. These instruments will be enclosed in a package about the size of a bread box.

HIG gyros, based on a concept originated by the Massachusetts Institute of Technology, were developed by Honeywell aeronautical engineers to provide ultra-accurate flight measurements needed in aircraft, rocket and missile control systems. An HIG is so accurate it can sense movement 3,000 times slower than the movement of an hour-hand on a watch. If a man standing in Los Angeles, Calif., could read a newspaper in New York, N. Y. the HIG could measure the angle formed by movement of his eyes, from one side of the page to the other.

The Vickers autopilot unit will be a magnetic amplifier which is akin to the electronic or radio vacuum tube in many of its performance and functional features.

However, in contrast to the relatively short-lived glass enclosed vacuum tube, the magnetic amplifier is extremely rugged and shock-resistant and has a long life span. In physical appearance, the magnetic amplifier has somewhat the same characteristics as a transformer. The high-grade electrical steels and intricate circuits used in the design and manufacture of these units, however, removed them from the transformer category, and have caused them to be used in many applications where vacuum tubes of necessity were formerly used.

In its orbit, the satellite will circle the earth, radioing back information about upper atmosphere. It will travel around the earth in an elliptical course, sometimes 300 miles from earth and at others as much as 800 miles away.

Project Vanguard is part of the IGY United States' scientific program sponsored by the National Science Foundation and the U. S. National Committee for the IGY, established by the National Academy of Sciences.

Department of Defense participation in the earth satellite program is on a three-service basis, with U. S. Navy management under the Chief of Naval Research. The Naval Research Laboratory has the responsibility for the production, launching, and radio tracking of the satellite. The Martin Company of Baltimore is the prime Navy contractor for the satellite launching vehicle.

Outstanding Television Sessions at SMPTE Meeting

The cold war that existed between motion pictures and television has changed to active co-operation, it was stated by Dr. J. G. Frayne, president of the Society of Motion Picture and Television Engineers (SMPTE), speaking at the Society's 79th convention in New York, N. Y., April 30–May 4, 1956. While co-operation has long been known to engineers, evolution of compatible business relationships "has followed by 10 to 15 years the meeting of the technical minds."

Although founded in 1916 as the Society of Motion Picture Engineers, in 1950 it changed to the SMPTE, as interest among Society members in television existed for many years. Television played an important part at this convention, with half of the 20 technical sessions devoted exclusively to television subjects.

General features of a new videotape recorder and its usefulness in the forseeable future were presented by R. H. Snyder, Ampex Corporation. It records continuously for 64 minutes, using 4,800 feet of 2-inch magnetic tape on a 14-inch diameter reel, comes to full stable operating speed in 4 seconds from dead stop, and rewinds in 1 minute 40 seconds. Mr. Snyder stated that it might be possible for a motion picture director to shoot scenes simultaneously in film and in videotape and immediately review the tape recording.

Enough different types of closed-circuit television equipment are readily available to meet any viewing problem, and in a variety of ways, it was stated by J. R. Howland, Thompson Products, Inc. Among the uses which Mr. Howland noted were transmitting signatures, ledger cards, and records, observing machinery functions, guarding against pilferage, monitoring traffic movements, enhancing advertising agency test presentations, inspecting well pipes, atomic reactors, or cockpits of test planes, and enlarging and displaying the field of a microscope.

The possibilities opened up in the field of

underwater observation by the use of television were revealed by Douglas Allanson, Pye Limited, Cambridge, England, who explained that a television system specifically adopted for underwater observation must be reliable, rugged, compact, simple to operate, easy to maintain, and preferably inexpensive.

Television is an important weapon available to the military commander in his battle to acquire a rapid and accurate intelligence and communications system, it was stated by Lt. Colonel Norman Gray, Army Pictorial Center. He said constant improvements have been made in military television systems since 1948, when the first unit was contracted for by the U. S. Signal Corps. Latest developments include a "man-pack" light and compact combination television chain, power unit, and transmitter weighing only 55 pounds.

Color Television Helps Radioactive Area Work Performance

Scientists are now using specially designed color television to help them perform work in radioactive areas at the Hanford plutonium plant operated by General Electric (GE) for the Atomic Energy Commission (AEC).

Crane operators who formerly observed their work in one of the "hottest" Hanford areas by means of a periscope now have a color closed-circuit television system, supplied by GE's Broadcast Equipment Section at Syracuse, N. Y. High image brilliance on the television screens and added depth perception afford easier operation of giant crane hooks.

Two cameras mounted in the radiation area of the building where plutonium is extracted from fissioned uranium are used to give operators a clear, wide-angle view of chemical equipment.

The cameras, attached to the crane bridge, are connected by wire with two receivers in the cab. Two 7-inch screens on receivers give the same view as 10-inch screens because of magnifying systems. Complete remote control of the cameras is obtained from the crane cab. This control includes all electronic adjustments, pan, and tilt.

The crane cab is windowless and has thick steel walls. It is located behind a thick concrete parapet to protect operators from radiation emanating from the chemical separations zone 80 feet below the crane.

According to GE broadcast engineers, color television was chosen primarily because the remote manipulation problem involves color coded objects and also because it gives added depth perception and better object resolution.

The television system uses the rotating color wheel principle, it was explained, because of the resulting economy, color rendition, definition, and low maintenance cost. Such a color system also has the advantage of simplicity of equipment.

The system also has applications in many other remote control assignments in atomic and other plants.

Stereo television would be another step forward since it affords increased depth perception. GE broadcast engineers say that use of larger monitor pictures will aid the operator of the crane because of reproduction of detailed information in the larger size screen.

Rubber Blankets Increase Production and Cut Costs

Thin, rubber electrical blankets are "putting the heat on" many industries to increase production and cut costs.

About 1/8-inch thick, the blankets are flexible and can deliver quick, even heat to hard-to-get-at places cheaply and simply. Some of the jobs they are doing in industry are melting ice, curing glue lines, preheating plastics, liquefying solids, speeding up chemical reactions, heating cargo, warming food, incubating, and dehydrating.

The Us-kon blankets, as they are called, are made by United States Rubber Company. They heat by electricity, using a conductive rubber element instead of heating wires, and can be bent around corners, stuck into crevices, wrapped around objects or applied between surfaces and put under pressure. They can be glued to almost any surface and nailed or stapled along the edges.

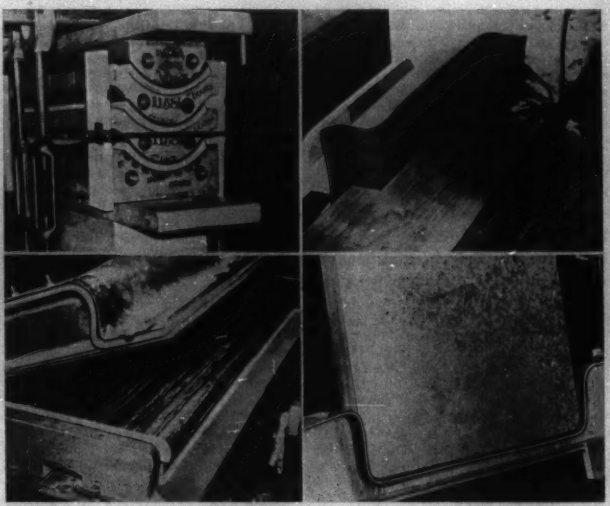
A Michigan furniture manufacturer reports that he is drying the glue line in his bent plywood lay-ups for chair backs seven times faster and has increased his production by that amount. A Us-kon blanket is used under pressure between the plywood and the male mold. The blankets will take up to 200 pounds pressure per square inch.

A plastics laminator in Indiana has eliminated wooden dies which had to be changed with each change in the shape of the furniture by using the blankets suspended in a metal frame. The hot blanket is sucked down onto the part to be laminated by vacuum pressure. It follows the slightest deviation in flat surfaces and around a curve. The firm laminates various plastics to plywood for sink tops, vanity tops, table tops, and custom work. It reports vast savings in labor and time over the old method of threading electrical wires through wood frames in order to get a hot cure. An official of the firm stated that the cumbersome apparatus needed for edge work has been eliminated and instead of an eight or ten hours period a six-minute production cycle is obtained simply by drawing a blanket tight around the edge.

Other laminators are using the hot blankets under vacuum pressure to laminate thin sheets of plastic to expanded plastics, honeycombed phenolic-impregnated paper cores, and various metals.

In Georgia, a manufacturer of commercial refrigerating units cements the blankets to the drain pans of his units to melt drop ice during the defrosting cycle. This allows the pan to drain clear and wash itself. Now a trucker does not have to stop on the highway to dig out the dirt that collected between the heating cables that formerly were used in the drain pans.

A wallpaper manufacturer in Jersey City, N. J., has simply spread an Us-kon blanket on a 30-foot by 36-inch table. Wet screenprint on the wallpaper dries completely by the time the paper has been pulled over the hot blanket to the end of the table. High drying efficiency is due to direct contact with the



FOUR TYPICAL applications of Us-kon, a thin, rubber, electrical blanket made by United States Rubber Company. *Upper left:* The glue lines in this bent plywood lay-up for chair backs are being heat-cured under pressure seven times faster than the old cold cure. Us-kon blankets may be seen between the plywood and the male mold. *Upper right:* Use of the blankets for edge sealing a plastic surface to an inside curve of a section under pressure has eliminated the cumbersome apparatus formerly needed. *Lower left:* A 10-hour glue cure has been reduced to 10 minutes. Plastics are laminated to flat surfaces with rounded edges by vacuum pressure. The Us-kon blanket is suspended in a metal frame and is sucked down onto the part to be laminated by vacuum pressure. *Lower right:* A furniture firm laminates an outside curve in a jig under heat and pressure in only six minutes with rubber blanket between the jig and the edge of table top.

heat. It is a continuous process and gives better quality. Other advantages are better utilization of floor space and savings in capital investment. The old tunnel and equipment necessary to heat air and blow it through the tunnel to dry the screenprint have been eliminated. Also gone is the possibility of dust and dirt being blown through and getting into the colors. There is much less mechanical trouble since there are no moving parts except the usual roll-making unit at the dry end.

In the drug industry, the blankets are wrapped around pipes to maintain gelatin flow and warm solutions. Industries handling viscous materials use them to increase flow in cold weather. Utilities keep gas lines and valves free of ice, road builders liquefy tar, instrument makers keep parts at constant temperature to insure accuracy, restaurants hold food on warming tables, and the chemical industry has wide and varied uses for the blankets.

The blankets have a sandwich-like construction. In the center is a paper-thin layer of rubber which conducts electricity instead of insulating against it like rubber normally does. This is vulcanized between two sheets of nonconductive neoprene rubber. The conductive rubber is energized by a flat conductor which runs along only two parallel edges of the blanket under the neoprene cover.

The two conductors connect to a lead wire outside the blanket which is plugged into an electrical source. Under thermostat control, the blankets reach temperatures up to 220 F. They operate on 115 or 230 volts in almost any wattage desired and weigh from 8 to 16 ounces per square foot. If punctured, the hole can be cut to a clean edge and sealed with an insulating mastic which the company furnishes, or the blanket may be cut across at that point at right angles to the electrical conductors to make two blankets by connecting new lead wires to the exposed ends of the conductors.

The blankets come in a wide range of sizes, in high wear resistant and in waterproof and chemically resistant constructions.

Laboratory Diamonds Reproducible for Industrial Use

General Electric's famous diamonds—unveiled last year as "a laboratory achievement"—are now being produced so successfully in a pilot-plant operation that man-made diamonds will have an important impact on American industry and defense.

"Home-grown diamonds will give the U.S. an independent source of a vital commodity," Dr. C. G. Suits, GE vice-president and director of research, said as he presented to the Smithsonian a cluster of the first diamonds made in the General Electric Research Laboratory at Schenectady, N. Y.

A 100-carat sample of pre-production diamonds surrounded the cluster of early laboratory diamonds presented for permanent historical record to Dr. Leonard Carmichael, secretary of the Smithsonian.

The display, which was mounted on a plaque for presentation to the Smithsonian, has at its center a cluster of some of the first diamonds produced in the GE Research Laboratory. Surrounding the tiny cluster are 100 carats of small industrial-grade diamonds produced in a pilot-plant at GE's Carboloy Department, which is now engaged in limited production of man-made diamonds.

Since 1954, when the first diamonds were made in the GE Research Laboratory in Schenectady, steady progress has been made in bridging the gap between the first experiments and the production line. It was pointed out that the two main areas of concentration are quantity production of man-made diamonds and achievement of a marketable price.

Courtesy GE Research Laboratory

DIAMONDS FROM RESEARCH have been presented to the Smithsonian Institution by General Electric. Dr. C. G. Suits, vice-president and director of research, is shown assembling a plastic container holding GE man-made diamonds.

Dr. Suits explained that the commercial importance of diamonds stems primarily from the incredible hardness, which is important in use as jewelry as well as in industrial use for cutting and grinding.

At present, diamonds are mined principally in Africa with a smaller supply from South America at the rate of about 2½ tons annually. Approximately 90 per cent are imported by the United States. The major portion goes into tools that grind, polish, cut, and saw. Industrial diamonds also are being stockpiled for defense. For industrial diamonds purchased in a typical year, the U. S. pays more than $50 million.

Several members of the scientific team that in 1954 made the first GE diamonds attended the presentation ceremonies, climaxing their own four-year research effort and a 125-year quest by scientists the world over to duplicate nature's hardest and most glamorous substance. In achieving success, the GE scientists subjected "a carbonaceous compound" to the highest combined pressures and temperatures ever attained, duplicating conditions that would be found 250 miles beneath the earth's surface.

The cluster is about three-sixteenths of an inch in diameter and is composed of many tiny stones, the largest weighing less than a hundredth of a carat. The 100-carat sample of small man-made industrial diamonds surrounding the cluster was produced by the Carboloy pilot plant. The small crystals, occupying a total space of approximately one cubic inch, were divided into separate compartments on the presentation plaque, having been graded in accordance to established sizes used for different industrial grinding and polishing applications.

No attempt is being made to make stones of gem quality and size inasmuch as the most important prospect from this discovery is that this unique substance can be made available for widespread use in manufacturing. Fortunately, 80 per cent—by weight—of the industrial diamonds now used by the U. S. are of the sizes that can be produced readily by this process.

Every known scientific test, including X-ray diffraction, has been used to prove that GE's diamonds are identical with those mined from the earth.

Dr. A. L. Marshall, manager of chemistry research at the GE Laboratory, stated that no one scientist could be singled out for receiving credit for what has been a fine example of the kind of team effort becoming increasingly prevalent in modern research. He cited the inspiring leadership of A. J. Nerad, head of the mechanical investigations section in which the work was done, and the four scientists who were assigned to the project in 1950: Drs. F. P. Bundy, H. T. Hall, H. M. Strong, and Robert Wentorf, and the efforts and contributions of two young assistants, James Cheney and Harold Bovenkerk.

Because of the potential defense importance of an independent supply of diamonds, all details of the GE process have been placed under a Government secrecy order. It can be told, however, that GE scientists—by constructing a special pressure vessel for use in large hydraulic presses—have achieved, and maintained for long periods, pressures of 2.7 million pounds per square inch at temperatures of 5,000 F.

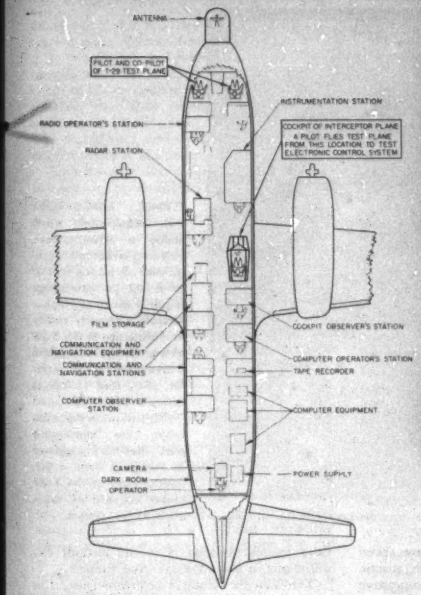
Plane within Plane Tests Jet Interceptors

A cockpit installed in the main cabin of a *T-29* airliner enables a back-seat pilot and 10 engineers to check new electronic control systems. Hughes Aircraft Company is flying a "plane within a plane," readying new weapons of defense for operation months ahead of time, it was revealed at a press demonstration at the company's plant in Culver City, Calif.

The important testing and checking results might be obtained in another way by having scientists and engineers hover around a one-man jet interceptor while it is in flight; but since their work would be hampered by the supersonic space suits they would have to wear, equal results are doubtful, it was pointed out.

Hughes Aircraft is now testing an advanced electronic control system for a jet all-weather interceptor plane by installing a cockpit and the interceptor's entire electronic control system plus test installations—two tons of equipment worth nearly a million dollars—in the main cabin of a *T-29*, which is the military adaptation of the Convair *240* commercial airliner.

The regular pilot takes the *T-29* aloft, then transfers control to a test pilot in the cabin cockpit. This "back-seat" pilot flies the



Courtesy Hughes Aircraft Company

Courtesy Hughes Aircraft Company

BACK SEAT FLYING (above) in cockpit installed in main cabin of T-29 airliner Hughes Aircraft Company engineer R. E. Moore is shown in "plane within a plane" where test pilots fly just as though they were in an *F-102* jet interceptor. Ten Hughes engineers simultaneously check operation of electronic control system developed for interceptors to seek, find, and destroy attacking enemy bombers. R. E. Ringe (*behind cockpit*) works at the observer's station and E. L. O'Brien works at the computer operator's station; (crouching, aft) N. L. Nelson adjusts computer test equipment. Flying laboratory layout (*left*) of *F-102* jet interceptor in the main cabin of a *T-29* airliner. Diagram shows location of major pieces of equipment.

plane as though it were a jet interceptor, operating its electronic "seek, find and kill" system while scientists and engineers check the performance of the system—and a psychologist checks the performance of the pilot!

Thus, this flying laboratory saves many thousands of dollars of taxpayers' money, inasmuch as a jet plane is expensive to fly and maintain, while the *T-29* is flown and maintained at one fifth the cost. It was further pointed out that not even one observer can go aloft in a single-place jet interceptor, but several scientists and engineers have elbow room to work simultaneously on the interceptor's electronic control system when it is spread out in the large, pressurized *T-29* cabin.

Hughes systems for interceptor planes are complex, with almost as many parts as 200 television sets, and are miniaturized for compact installation in the fuselage of jet interceptors now guarding this continent against enemy air attack. The systems can locate approaching enemy bombers at night and in any kind of weather, direct the interceptor to fly a correct course, and fire the interceptor's armament at precisely the right moment to destroy the target.

Each system is tailored to meet the requirements of the interceptor and its armament. In the *T-29* now being tested is an advanced electronic control system for the Convair *F-102*, newest of the U. S. Air Force's all-weather interceptors.

On the *T-29* nose is seen an extension, a radome covering the antenna for the *F-102*'s electronic control system. Inside is mock-up of an *F-102* cockpit, installed on the starboard side of the main cabin just aft of the wing.

When a test flight is scheduled, 13 men troop towards the flying lab. The *T-29*'s crew make ready the plane and take it aloft. On signal, the *T-29* pilot transfers control to an engineering test pilot in the *F-102* cockpit aboard, and tests begin.

The *T-29* is now flown with *F-102* controls in an *F-102* cockpit just as though it were a jet interceptor. Ahead of the test pilot an engineer seated at an instrument panel is busily calibrating and checking the operation of data recorders. Every movement of the "interceptor" and each slight action of its complicated electronic control system is being recorded; even all conversation of all personnel throughout the flight is preserved on tape.

Across the aisle another engineer checks performance of the radar portion of the Hughes system, and behind him two men maintain special navigation equipment and operate ground-mapping and instrument-panel record cameras.

Photography plays an important part in these *T-29* flights. Cameras focused on banks of dials and indicators record the complete story of each flight. In the radome, a camera attached to the antenna records its action as it searches up and down, back and forth, and "tracks" a target. The target itself is photographed by cameras bristling out of the fuselage of the *T-29* in different directions.

A camera in a gyro-stabilized mount takes pictures of the ground and is so linked into a timing system that when the developed films are studied in conjunction with other information the position of the plane at each instant is closely determined, important because navigation is an integral part of interceptor system performance.

Just aft of the cockpit sits a "cockpit observer," evaluating the psychological aspects of the cockpit's instrument arrangements, colors, and lighting, and noting the pilot's reactions. Farther back in the cabin two engineers check the performance of the computing elements, one of them correlating theory with this practical computer operation. Often the thirteenth man on board for a flight is a second pilot for the *F-102* cockpit, so that different human reactions can be studied under similar conditions.

When an electronic control system is taken aloft in the *T-29* it is "experimental hardware and circuitry" in a "breadboard" status, meaning that it has yet to be squeezed, or miniaturized, into a production design to slide into a small, supersonic plane. Before the system arrived at the *T-29* stage "hot off the experimental bench" its components underwent intensive analysis and simulation in a laboratory, then it was tested as a system in a Hughes "roof-house" laboratory. Following *T-29* flights the system is tested in the actual airplane it is designed for, in this case the *F-102*, and is put into final design and production.

A pilot alone in a plane like the *F-102* can make very few adjustments in an electronic control system during flight. However, in the *T-29*, many experts may make many adjustments. If some unit or "black box" proves troublesome it can be quickly replaced, a procedure the hypothetical engineer in the "supersonic space suit" would find difficult to accomplish on an *F-102* in flight.

Many electronic control system changes must be made and evaluated one at a time, otherwise the effects of one change are camouflaged by the others. In an inter-

FLYING LABORATORY with equipment worth nearly a million dollars, including a cockpit (foreground) simulating that of an *F-102* jet interceptor (*right*) is shown at Hughes Aircraft Company ready for installation in the *T-29* airliner (*left*). Test plane is taken aloft by its regular pilot, then control is shifted to pilot in simulated *F-102* cockpit in the main cabin; the "interceptor pilot" flies the big airliner as though it were a jet. Special nose on the *T-29* houses antenna of electronic control system.

Courtesy Hughes Aircraft Company

ceptor, this means one flight per modification evaluation; in the *T-29* flying laboratory, many modifications can be made in series on one flight. The increase in test information yield is extremely high and consequently very valuable.

Reactor Safety Experiments Made by New York University Scientists

A two-million volt Van de Graaff particle accelerator has been teamed by New York University (NYU) scientists to its subcritical "pickle barrel" nuclear reactor. The result is that the NYU reactor can now be used for research as well as for educational purposes.

This combination of the Van de Graaff "atom smasher" and the pickle barrel reactor makes possible research on problems affecting full-scale reactors.

Full-scale safety experiments with the new research tool have already been begun by NYU scientists.

The experimenters have succeeded in turning the reactor on and off in 10-millionths of a second (10 microseconds), which is record time and means the first practical step in model scale study of reactor surges. Previously, the fastest reactors were triggered in a matter of thousandths of a second (milliseconds), 100 times slower than now is possible with the new apparatus.

One of the first tasks envisioned for the new tool is a study of the "overheating" of full-scale research and power reactors. At this stage of nuclear development, it is essential that calculations of a reactor's kinetic behavior be backed up with experimental observation. The consequences of a reactor "blowup" are too great and experience too limited to do otherwise. Advances in reactor safety are increasingly important in view of the fact that, since the first nuclear energy generated electricity for public use was produced in West Milton, N. Y., last year, several other communities have asked for nuclear electric plants, although atomic power is not yet economically competitive with coal.

Planned tests of full-scale reactors are time consuming and quite costly—approximately $500,000 per test.

Thus, the research program planned for the NYU facility would make data on reactor behavior available at a small fraction of the cost of full-scale evaluation. Inasmuch as the subcritical assembly is an accurate mirror image (in terms of physical behavior, not design) of full reactors, the results can be extrapolated.

The ticklish period in reactor operations comes as the nuclear furnace is brought up to power. This is the time when fissions may multiply beyond control, generating more heat than can be channeled off and producing excessive radiation. (Once the reactor has reached its operating level, it can easily adjust itself to fluctuations in fission activity.)

This crucial build-up period may be studied in the assembly at NYU without danger because the pickle barrel is incapable of operating at a power greater than one watt. The fuel is unenriched uranium metal, in which there is only 1 part of fissionable U-235 to 140 parts of U-238.

In its original form, the pickle-barrel reactor used as a neutron source two grams of radium-beryllium.

In the proposed experiments, reactor surges will be studied by shooting a beam of neutrons into the subcritical assembly. The precision of the Van de Graaff makes it possible to deflect the beam in 10 microseconds, a tremendous advantage in accuracy over the mechanical means of directing the beam involved when radium-beryllium is used as a source.

Should extrapolation of subcritical reactor behavior under a power build-up be verified, new reactor designs could be tested in small scale. In effect, this would be a nuclear version of model aircraft experiments in aeronautical wind tunnels.

The Van de Graaff accelerator raises the power by a factor of 1,000, to 3 watts, and the neutron production to 100 billion per second.

The pickle-barrel reactor consists of two tons of unenriched uranium metal rods on loan from the AEC. It is subcritical, and therefore, safe, economical and adaptable to student use.

The Van de Graaff particle accelerator is manufactured by the High Voltage Engineering Corporation of Cambridge, Mass. It is a modern version of one of the first atom smashers ever developed in the 1930's. It is basically a device that speeds up atomic particles to great speeds, and then fires them at a target in much the same way as a gun fires a bullet. The new combination can also be used for neutron cross-section measurements, which have been a key problem in nuclear science.

Nuclear Power Plants for Minnesota and Michigan Electricity

The Atomic Energy Commission (AEC) has approved in principle, as a basis for negotiations, the nuclear power plant proposals of the Rural Co-operative Power Association of Elk River, Minn., and the Wolverine Electric Co-operative of Big Rapids, Mich. These were among seven proposals made in response to the second invitation of the AEC under its Power Demonstration Reactor Program, calling for development, design, construction, and operation of plants with capacities within the 5,000 to 40,000 kw range.

This AEC action opens the way for negotiations which will determine the kind of assistance to be given the co-operatives and will establish the cost limits of this assistance Contracts for the assistance will be contingent

on approval of Rural Electrification Administration plans requested by the co-operatives.

In accepting the proposals as basis for negotiations, the AEC determined that the types of plants contemplated are technically feasible, that they represent desirable extensions of development work now under way or planned, and would make important contributions to the power reactor art.

Both co-operatives proposed that the AEC finance and retain title to the reactor portion of the plant.

A closed cycle boiling water reactor plant with an electrical capacity of 22,000 kw was proposed by the Rural Co-operative Power Association. The Co-operative would assume capital costs totaling $2.45 million, including the value of the site. The AEC would be asked to contribute a maximum of approximately $6.86 million for the development, design, and construction of the reactor and post-construction research and development work. The AEC also would be asked to waive the use charge for the fissionable material which will fuel the reactor.

The Wolverine Electric Co-operative, on the other hand, proposed an aqueous homogeneous reactor plant with 5,000 to 10,000 kw electrical capacity. The Wolverine Co-operative would assume capital costs in excess of $1.08 million, including value of the land site. A request for the maximum AEC contribution of $3.79 million for development, design, and construction of the reactor was also made.

There were five other proposals which are still being evaluated by the AEC staff. They are: (1) Chugach Electric Association, Anchorage, Alaska, and Nuclear Development Corporation of America, White Plains, N.Y.—a sodium-cooled heavy water moderated plant of 10,000 kw electrical capacity; (2) City of Holyoke Gas and Electric Department, Holyoke, Mass.—a gas-cooled reactor with closed-cycle gas turbine of 15,000 kw electrical capacity; (3) City of Orlando, Fla.—a liquid metal fuel reactor of 25,000 to 40,000 kw electrical capacity; (4) City of Piqua, Ohio—an organic moderated reactor plant of 12,500 kw electrical capacity; and (5) University of Florida, Gainesville, Fla.—a pressurized light-water reactor plant of 2,000 kw electrical capacity.

Special Courses Offered by Institutions

Lightning Arrester Training. A lightning arrester training program for electric utility engineers is offered by Westinghouse Electric Corporation. There will be four seminars, each two hours in length. A Westinghouse engineer will conduct the course the first time it is given to each utility. The utility engineer who works with the instructor during the first course can conduct all subsequent courses.

Postdoctoral Award Program. Applications will be accepted through September 4, 1956, for the second group of senior postdoctoral fellowships to be awarded by the National Science Foundation during the current calendar year. Fellowships will be awarded in mathematical, physical, medical, biological, engineering, and other sciences, including anthropology, psychology (other than clinical), geography, certain interdisciplinary fields, and areas of convergence between the natural and social sciences. Names of successful fellowship candidates will be announced on October 16, 1956.

Lecturing in Egypt. Funds have recently been made available to continue the Fulbright program in Egypt through the academic year 1956–57. University lecturers have been requested in the following fields: Journalism, University of Cairo, September 15, 1956 to June 1, 1957; English Teaching and Linguistics (four awards), September 1956 to June 1957; Social Service, Higher Institute of Social Service, Alexandria, October 1, 1956 to May 15, 1957; Experimental Nuclear Physics, University of Cairo, October 1956 to June 1957; and Chemical Engineering, University of Alexandria, October 1956 to June 1957. Fulbright awards, based on academic year periods, include round-trip transportation for the grantee but not his family, plus maintenance for the grantee and his family (up to four dependents) calculated on the cost of living in the host country. Lecturers are expected to have had at least one year's college or university teaching experience; limited to citizens of the United States. Applications are obtained from: Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, N.W., Washington 25, D.C.

AMA Summer School. The American Management Association, during July and August, through the management educational association will hold some 60 seminars, courses, and small-group conferences as part of its second annual series of summer meetings at Colgate University, Hamilton, N.Y. The AMA summer school will start July 9. The enrollments are for one week each, with a program that will be on a seven-hours-a-day schedule with morning, afternoon, and evening sessions.

Evening Graduate Studies for Masters Degrees. Worcester Polytechnic Institute is offering in the Fall a full program of evening graduate study leading to the Master of Science Degree in Electrical Engineering, Mechanical Engineering, and Physics. A minimum of 32 semester hours will be required for the degree. Courses of graduate study in other departments will be instituted as demand warrants.

Computation Laboratory Summer Program. Wayne State University is offering three weekly courses from July 23 through August 11, 1956, in automatic computers, their application and evaluation; electronic data processing in business and government; application of computers to engineering, science and industry. Additional information is available from: A. W. Jacobson, Director, Computation Laboratory, Wayne University, Detroit 1, Mich.

Oak Ridge Science Demonstration Lecture Program. The National Science Foundation and the United States Atomic Energy Commission are cosponsors of the program to be administered by the Oak Ridge Institute of Nuclear Studies, University Relations Division, which will take eight high school science teachers and give them a special three-month training course at ORINS this summer, and then spend nine months of the 1956–57 school year visiting high schools throughout the country, where they will present demonstration lectures to the science students and confer with faculty members on science teaching problems.

Atomic Energy and Science Symposium. The ninth Oak Ridge regional symposium will be presented July 30–31, in Blackburg, Va., sponsored by Virginia Polytechnic Institute, in cooperation with the Oak Ridge Institute of Nuclear Studies. It will include an exhibit from the American Museum of Atomic Energy in Oak Ridge, as well as the General Electric Company film, "A Is for Atom."

Simulation and Theory of Traffic Flow. A two-week course on Simulation and Theory of Traffic Flow has been planned to be held from September 10 through 21 on the Los Angeles campus of the University of California. A limit of 40 students has been set for the course, which will serve as an introduction to computers, numerical methods, preparation of problems for a computer, mathematical models, probability, stimulation techniques, evaluation of computer equipment, and application of these techniques to traffic problems.

Nuclear Reactors and Radiations in Industry. The second annual two-week intensive summer course will be given in Ann Arbor, Mich., from August 20 through 31, at the University of Michigan, College of Engineering. The course will cover such topics as elementary nuclear theory, measurements of nuclear radiations, interaction of radiation and matter, and nuclear reactors and fuels, coordinated with laboratory demonstrations, tours of university radiation facilities, and examples of industrial applications. Additional details are available from: Prof. William Kerr, Department of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

Five-Year Co-operative Program. A new five-year co-operative program known as the "three-two plan" will enable a student to attend Western Maryland College for three years followed by a two-year program at the University of Maryland. Graduates of this plan will receive both the Bachelor of Arts degree from Western Maryland College, and the Bachelor of Science engineering degree from the University of Maryland. This new plan will go into effect in September 1956.

Noise Abatement Advanced by New Portable Instrument

A new electronic instrument to aid the fight against one of the country's most troublesome safety problems—industrial noise—has been introduced by Mine Safety Appliances (MSA) Company, Pittsburgh, Pa.

The instrument is the first that combines in a single portable unit four principal functions necessary to measure and analyze noise accurately. Acoustical engineers, industrial hygienists, safety directors, industrial designers, audiologists, city planners, speech experts, and many others concerned with the problem can use the instrument to track down and measure hazardous noises.

Called "Soundscope," the instrument serves as a meter to measure over-all sound levels. It also operates as an analyzer, measuring sound in each of eight octave

bands to determine noise peaks. In addition, it can check sounds in narrower frequency bands. Electrical and acoustical calibrators are built into the unit.

The 20-pound instrument takes the place of four individual units previously required for noise analysis. It is expected to play an important part in efforts to control noise, which the American Standards Association reports has resulted in $2 billion worth of claims being filed against industry.

In addition to its use in noise abatement programs, the new instrument is said to aid manufacturers in eliminating undesirable sounds from autos, household appliances, and other products with moving parts that cause noise. Municipal authorities also can use it to check compliance with noise ordinances. It can be employed by engineers in architectural design work. Scientists studying human speech may find it helpful in their research efforts.

Because the instrument is portable, self-contained, simple to operate, and incorporates necessary analytical features, its widest use will be in the field of industrial noise prevention to combat occupational loss of hearing.

During a conference held in connection with the introduction of Soundscope, Dr. L. G. Doerfler, professor of audiology at the University of Pittsburgh School of Medicine, branded industrial noise as a "public problem." Although millions of dollars in damage suits for occupational loss of hearing are the direct concern of industry, the public eventually will share the cost.

Dr. Doerfler, who also is director of audiology at Pittsburgh's Eye and Ear Hospital, described occupational loss of hearing as an insidious affliction because in the early stages it is completely unnoticed by the victim. The damage caused to thousands of sensitive auditory nerve endings in the inner ear by exposure to excessive industrial noise cannot be repaired. Vibrational energy withers nerve tissues which do not regenerate. This hearing loss, he said, is irreversible. Use of hearing aids is extremely difficult and in many cases impossible.

Another noise control expert, K. C. Stewart, research associate at the University of Pittsburgh's Graduate School of Public Health, pointed out that the loudest noises do not necessarily cause the most damage. The frequency of sound must be measured along with intensity, or loudness, to determine the degree of hazard.

Over-all noise level measurements provide little indication of what specific frequencies are causing the problem. A single industrial machine can produce sounds of many different frequencies with widely varying intensities. Each frequency band must be studied individually to locate the potentially harmful noise source so that corrective action can be taken.

Because all sound is a form of energy, intensity or loudness depends on the amount of energy used to produce the sound wave. The size of the surface radiating the wave also is a factor in sound intensity.

What makes the industrial noise problem so complex is the human factor. Although noise intensity and frequency can be measured, the effect on human hearing is governed by variables of age, physical condition, duration of exposure, and other elements.

With the new MSA Soundscope, it will be possible to make noise contour maps of industrial areas. Sound level readings and analyses of frequencies and intensities at different distances from noise sources can be used to plan a detailed map of an area indicating unsafe locations.

To determine whether a noise hazard exists and to locate the sources are Soundscope functions. Circuits and instrumentation of the unit meet pertinent specifications of the American Standards Association for sound level meters and analyzers.

Each of 14 tubes is mounted on a shock-absorbing pad and the first tube in each amplifier unit is encased in a metal shield. Subminiature vacuum tubes are used, along with printed circuits, to reduce the size of the instrument as well as to prolong the service life of the seven dry-cell batteries that supply power.

The entire instrument measures 16 inches long, 7¾ inches wide, and 7 inches deep. It is enclosed in a wood and aluminum case that serves as a mechanical and electrical shield. All control dials are located on one panel and readings are indicated by a single meter, which is calibrated in decibels.

Measurement range is from 24 db, about that of a very quiet home, to 150 db, which is considerably higher in sound pressure than an air-raid siren. The relative energy between these two extremes is far greater than the numerical db difference indicates. A 60-db reading, for example, is equivalent to one million energy units while 120 db is comparable to one trillion—a million times greater. An increase of only three decibels in sound intensity more than doubles the vibrational energy of noise reaching the ear.

In the analyzer section of the instrument, noise is filtered into any of the eight principal octave bands, from 75 to 19,200 cps. Noise peaks in each of these bands then can be measured individually. For finer analysis, by frequencies within the octave bands, continuously variable filters are used.

Importance of breaking sounds into frequencies to measure intensity levels is based on investigations which show that the ear is more susceptible to some frequencies than others. Thus, technicians can determine accurately the offending frequencies.

TRACKING DOWN potentially harmful industrial noises is the job of a new electronic instrument, the Soundscope, developed by Mine Safety Appliances Company, Pittsburgh, Pa. A technician *(right)* takes sound pressure level readings at a punch press. The press operator *(left)* is wearing MSA Noisefoes, earmuff-type protectors that guard against noises.

Monoflo Conveyor Protects Atomic Scientists

A unique feature of the Monoflo conveyor has been put to work at the Los Alamos Scientific Laboratory where the Chemistry and Metallurgy Research Division has employed Monoflo inside "dry boxes." These "boxes" are shielded chambers which safely enclose radioactive materials without danger of contaminating the worker while he is handling these materials.

The feature which makes Monoflo useful in this application is the fact that although the item to be conveyed moves through an area smoothly at a controlled speed, and

MONOFLO CABLE conveying "dry boxes" which safely enclose radioactive materials.

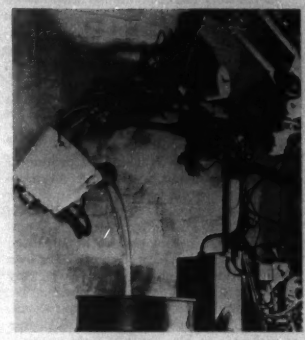
can be stopped at any point in its travel, the conveyor itself does not move out of the area. The Monoflo conveyor consists of a flexible steel cable with a spiral outer surface. This cable is retained in a metal casing or rail with an open top just large enough to expose the spiral. The cable is rotated by means of a motor drive coupled to one end and it is this rotation which causes any load hooked over the cable to be propelled forward by the spiral. Thus, unlike the conventional chain or belt conveyor which moves with the load, the Monoflo cable and its supporting rail remain in place while the load moves ahead.

Thus, in a case where material is to be moved into and out of a contaminated area, the loading portion of the conveyor is always safe since it never moves through the radioactive zone. As the material is conveyed out of the "dry box" it is not necessary to

GE News Bureau Photo

GE News Bureau Photo

THE MOST DEXTEROUS mechanical slave ever developed, General Electric's "Yes Man," *(top left)* shows its ability by drawing a house in a laboratory demonstration. Operated by an engineer seated at the "master" machine some distance away, "Yes Man" selects a drawing pencil with his left hand and sketches the house with his right hand. "Yes Man" helps girl *(top right)* into her coat during demonstration at General Electric's General Engineering Laboratory. "Yes Man," the servo manipulator has muscle as well as dexterity and can serve as a mechanic in radioactive work areas. While the slave's left arm lifts a full pail of water *(right)*, the right hand tips the pail to pour the water into the center of a barrel.



GE News Bureau Photo

handle either it or the hook by which it is suspended, since by terminating the Monoflo conveyor over a shielded container, the radioactive load automatically drops off the end of the conveyor into the container.

The flexibility of Monoflo cable permits it to follow paths with horizontal and vertical curves, and standard rail sections and fittings are available from stock to make up such multicurved systems.

Monoflo conveys loads up to 15 pounds each at speeds ranging from 0 to 12 feet per minute and can be arranged so that the load can be picked off at the end of the conveyor, allowed to drop off at the end, or all the loads can be accumulated at the end on a storage rail.

Mechanical Slave Performs at Master's Bidding

A two-armed electro-hydraulic "slave" that could perform sensitive mechanical tasks in New York, N.Y. at the bidding of its "master" in San Francisco, Calif. has been developed by General Electric (GE) engineers.

Nicknamed "Yes Man" by its creators, the new machine is the most dexterous master-slave manipulator yet devised. It is designed primarily to do the work of a mechanic in radioactive areas in which it is too dangerous for a mechanic to work.

"Yes Man" is actually twins, having two almost identical pairs of mechanical arms and hands that somewhat resemble a dentist's drill rigs. The "slave" is a virtual twin to the "master," except that it has claw-like fingers on each hand and has no operator's seat. Its arms, elbows, wrists, hands, and fingers are electronically geared to duplicate simultaneously the exact motions of the "master."

To perform a given mechanical task, the operator seats himself in the "master" seat, straps his own arms and fingers into the mechanical arms and fingers, and watches the "slave" duplicate each motion he makes.

This latest advance in mechanical hands was developed and built in General Electric's General Engineering Laboratory, Schenectady, N.Y., for the company's aircraft nuclear propulsion department under contract with the U. S. Air Force.

The same laboratory earlier developed "O-Man," the world's largest and strongest mechanical arm.

"Yes Man's" forte is dexterity. It has two fingers and a thumb on each hand, plus wrists and elbows, to give it wide flexibility.

Instead of pushing buttons and controls, the operator actually goes through the desired arm and finger motions for the task at hand. Operating the "master" machine, he actually can "feel" the force encountered by the slave as it tackles a job.

This sensitive touch enables him to control the slave with high proficiency in handling a wrench or a screwdriver, pouring water, placing objects, or virtually any other mechanical chore.

It permits him to perform intricate operations in hazardous radioactive areas remotely and at a safe distance.

Were the slave on the Atlantic coast and the master on the Pacific coast, "Yes Man" would require many telephone channels and, to see what he's doing, one television channel. Despite the mileage, the operator in San Francisco, Calif., could still "feel" what the slave in New York, N. Y., was encountering. Normally the distances are nowhere near as large and the problem of interconnecting master and slave is simpler.

This unprecedented design gives "Yes Man" a big jump and makes it more dexterous than any known manipulator. Although not the strongest manipulator ever built, it is the strongest "spatial correspondence" system yet devised—that is, the strongest manipulator giving the operator the advantages of controlling many complex motions in a "normal" manner without having to think about which push buttons must be operated to achieve the desired motions. It can lift up to 100 pounds in certain positions and 25 pounds in any position.

The system consists of two master arms, one left and one right, each with two fingers and a thumb; left and right arms on the slave with corresponding finger arrangement; two separate hydraulic pumps, a rack of electronic amplifiers, and two groups of electro-hydraulic valves.

The electro-hydraulic valves convert the electrical signal into hydraulic power, which in turn operates the slave and gives the master its ability to "feel."

The slave can be mounted on a variety of devices to extend its work area—overhead cranes, rollers, a dolly, remote control truck, or whatever is practical to obtain access to its work.

The developmental model built in the Schenectady, N. Y., Laboratory is currently undergoing operational tests. GE engineers are already experimenting to make the machine's hands even more dexterous.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Franklin's Gift to EE

To the Editor:

The article in your January issue, "Benjamin Franklin's Gift to Electrical Engineering," is very interesting. And Mr. Franklin contributed other items of help to the development of American civilization. One of these, according to records of old times, was the selection of proper color of paint for fire engines.

As the story has been handed down, when the Philadelphia people built their first fire engine there was a pile of argument concerning the color of paint which should be used on it. Although that engine was a wagon affair with water tank and a hand-pumping device to be operated by a gang of men, it was the first of its kind and should have an appropriate decoration of paint. So what color should be used?

At that time Mr. Franklin was prominent in public affairs and should have had an opportunity to express his opinion. There being considerable opposition to him on the part of local politicians of other parties, he knew very well that any idea which he advanced would be ridiculed most viciously. His own choice was red paint. So he replied, "Any color except red. I detest that color."

As a result, the engine was painted red, and that color has been used on fire engines ever since. So Mr. Franklin most certainly understood how to deal with people.

Thanks for the mentioned article. And with best regards,

Sincerely,

L. C. JORDAN

(Consulting and Designing Engineer)

EDITOR'S NOTE: L. C. Jordan, whose signature appears at the close of the foregoing letter, is neither related to nor acquainted with C. L. Jordan, the author of the article to which reference is made.

Kilowatt-Hour Weight

To the Editor:

I have been reading with interest the various opinions expressed as to the weight of a kilowatt hour. I agree with those who consider the question to be based on Einstein's Mass Energy equation, but in all the presentations I have read, the fundamental definitions have been neglected, and handbook values erroneously used. Therefore, to add to the store of theories on this subject, I have worked the problem as follows:

$$F = d(mv)/dt = [m\,dv/dt] + [v\,dm/dt] \quad (1)$$

$$m = m_0 \Big/ \left(1 - \frac{v^2}{c^2}\right)^{1/2} \quad (2)$$

therefore,

$$W = mc^2 = mc^2 + {}^1/_2 mv^2 \quad (3)$$

If we restrict the case to one which eliminates high electronic velocities, the mass involved will be approximately equal to the rest mass and the v^2 will be of little consequence.

$m_0 = 36(10)5/9(10)^{16} = 4(10)^{-16}$ kilogram

Since we have neglected the relativistic change in mass, we can disregard the second term of equation 1; and since weight is actually a force exerted by the earth, it can be expressed by what is commonly known as Newton's Second Law.

$$F = ma = w = mg \quad (4)$$

Therefore,

$w = 4(10)^{-11}(9.8) = 39.1(10)^{-11}$ newtons

and the cost per pound is equal to $3(10)^{-2}/3.91(0.2248)(10)^{-10}$ dollars per pound

or $342,000,000 per pound

or $648,000,000,000 per ton

Very truly yours,

A. L. GIRARD

(Worcester Polytechnic Institute, Class of 1958)

Oil-Filled Cable Discussed

The letters which follow were sent to the Editor of *Electrical Engineering* for publication in the hope that the subject therein discussed would be clarified. They discuss certain points in paper 56-68, "Oil-Flow and Pressure Calculations for Self-Contained Oil-Filled Cable" and accompanying discussions, by F. H. Buller, J. H. Neher, and F. O. Wollaston published in AIEE *Power Apparatus and Systems*, April 1956, pp. 180–94. These comments and reply were not ready in time to be included with others published in the bimonthly.

Dear Mr. Buller:

I am much indebted to you for having sent me a copy of your and Mr. Neher's closing remarks in reply to my discussion of paper 56-68.

Unfortunately your letter dated 7th March only reached me the day before yesterday (3rd April) and I have not yet had sufficient time to study it thoroughly. I hasten to write, however, to point out a misunderstanding which has arisen regarding my comment No. 2.

The case considered in equation (7) is very important over-all, and not only in single cases where very heavy overloads of rather short duration occur. In fact, where directly buried oil-filled cables are concerned, it takes several days—not merely hours—to attain steady-state conditions after application of load. Therefore, the possibility of having to drop the load whilst cable temperatures are still changing must not be overlooked. A few practical examples in any case will show that—from the standpoint of transient variations in pressure—the position is worst when load is dropped *whilst* temperatures are still changing than *after* steady-state conditions have been attained. I should like to stress, therefore, that I do not consider the most important case involves the dropping of the entire load during steady-state conditions (as attributed by your comments)—but, rather, quite the contrary.

My comment was merely intended to clarify an inaccuracy in the method of calculating the maximum value of $\mu a'$ when load is dropped suddenly, which applies both when load is dropped during the time cable temperatures are still changing as well as after the cable has attained the steady state. But, as I concluded in point No. 2, the inaccuracy is only slight, and the simplification introduced by the authors in the method of calculation adopted in the paper is undoubtedly fully acceptable to all practical purposes.

I should be very grateful if, by taking the foregoing into account, it would be possible to amend the reply to my comment No. 2. In other words, to cancel the sentence attributing me with an idea which is not mine (on a point which, in my opinion, is of fundamental importance in the whole study of the problem).

Thank you very much for your kind co-operation.

Yours truly,

ING. ALDO MORELLO

(Copy to E. C. Day
Assistant Secretary for Technical Papers)

Dear Mr. Rich:

Referring to Mr. Morello's letter of April 5, he makes two points therein; first, that the pressure drop depends on the product $\mu a'$ rather than on the oil demand "a'" alone; and second, that this product will probably be greater when dropping a transient load before steady-state temperature is reached than when dropping the same load from a steady state because the value of μ will continue to decrease as the temperature rises and will be higher if only a partial rise is attained than it will be when full steady-state temperature is reached.

Both these points are well taken; however, we are still of the opinion that, in general, the most important case is the dropping of load from the steady state. The reasons for this opinion are as follows:

(a) Oil-filled cables are usually designed on the basis of dropping a steady-state load, rather than a transient load, since it is rarely that the user knows ahead of time what transients are likely to be encountered; and, hence, such information is not usually available at the time when the cable is designed.

(b) The dropping of a heavy load

shortly after it is impressed is an unusual operating condition. If the cable core is designed to take care of this condition, the size and cost of the cable will be increased materially; and it is questionable whether the resultant increase in size and cost is justified economically.

(c) If the core size of the cable is determined on the basis of dropping a steady-state load, and a heavy load is actually dropped before the steady state is reached, the result will be that the pressure in some parts of the core of the cable will drop below atmospheric pressure. While this situation is undesirable and could be serious if it persists for a long time or if it occurs often, it will do little if any harm if it happens only once or twice during the life of the cable and persists only for a short time, provided that the cable sheath and the accessories do not leak. By designing the cable for the dropping of load from the steady state, a "calculated risk" is taken; and experience to date indicates that this risk is negligible as a practical matter.

(d) If it is intended to use the cable on some kind of a load cycle where load changes are frequent, sudden, and violent, one may expect frequent, and perhaps protracted, periods of pressure deficiency if the cable is designed on the basis of dropping load from the steady state. In such cases, the taking of the "calculated risk" is probably not justified, and the

(*Continued on page 674*)

Solution of an Integral

To the Editor:

In the April 1956 issue (p. 402) of *Electrical Engineering*, B. L. Barquist sought the solution to the following integral:

$$I(u)=\int_0^{\pi/2}\frac{J_0(u\sin\phi)\cos^3\left(\frac{\pi}{2}\cos\phi\right)}{\sin\phi}d\phi$$

As noted by the editor, it belongs to the general class of Sonine integrals. However, the conversion is not immediately obvious; and after conversion there still remains the question of the practicability of computing the function $I(u)$ to a reasonable degree of accuracy with relative ease.

In the following, the conversion of $I(u)$ to a form of Sonine's first integral is shown. The integrated result is arranged in a double-series form in terms of spherical Bessel functions, and $I(u)$ is computed and plotted for values of u up to 4π.

First of all,

$$\frac{\cos^3\left(\frac{\pi}{2}\cos\phi\right)}{\sin\phi}=\frac{\cos^3\left(\frac{\pi}{2}\cos\phi\right)\sin\phi}{1-\cos^2\phi}$$

$$=\frac{\sin\phi}{4}\left[\frac{1+\cos(\pi\cos\phi)}{1+\cos\phi}+\frac{1+\cos(\pi\cos\phi)}{1-\cos\phi}\right]$$

$$=\frac{\sin\phi}{4}\left[\frac{1-\cos\pi(1+\cos\phi)}{1+\cos\phi}+\frac{1-\cos\pi(1-\cos\phi)}{1-\cos\phi}\right]$$

$$=\frac{\sin\phi}{4}\sum_{k=1}^{\infty}(-1)^{k+1}\frac{\pi^{2k}}{(2k)!}[(1+\cos\phi)^{2k-1}+(1-\cos\phi)^{2k-1}]$$

$$=\frac{\sin\phi}{2}\sum_{k=1}^{\infty}(-1)^{k+1}\frac{\pi^{2k}}{(2k)!}\sum_{m=0}^{k-1}\binom{2k-1}{2m}\cos^{2m}\phi \qquad (1)$$

Substituting equation 1 back into the original integral, one has

$$I(u)=\frac{1}{2}\sum_{k=1}^{\infty}(-1)^{k+1}\frac{\pi^{2k}}{(2k)!}\sum_{m=0}^{k-1}\binom{2k-1}{2m}\times\int_0^{\pi/2}J_0(u\sin\phi)\sin\phi\cos^{2m}\phi d\phi \qquad (2)$$

Equation 2 is a form of Sonine's first finite integral,[1] which can be integrated to give

$$I(u)=\frac{\pi^2}{2}\sum_{k=0}^{\infty}(-1)^k\frac{\pi^{2k}}{(2k+2)!}\times\left[\sum_{m=0}^{k}\binom{2k+1}{2m}2^{m-\frac{1}{2}}\Gamma(m+\tfrac{1}{2})\,J_{m+\frac{1}{2}}(u)/u^{m+\frac{1}{2}}\right] \qquad (3)$$

Now[2]

$$\frac{2^{m-\frac{1}{2}}\Gamma(m+\frac{1}{2})}{(2m)!}=\frac{1}{2^m m!}\sqrt{\frac{\pi}{2}} \qquad (4)$$

$$\sqrt{\frac{\pi}{2u}}J_{m+\frac{1}{2}}(u)=S_m(u) \qquad (5)$$

$S_m(u)$ are spherical Bessel functions or Stokes functions[3] which are tabulated. Substitution of equations 4 and 5 in equation 3 gives

$$I(u)=\frac{\pi^2}{2}\sum_{k=0}^{\infty}(-1)^k\frac{\pi^{2k}}{2k+2}\sum_{m=0}^{k}\frac{u^{-m}}{(2k-2m+1)!}\frac{S_m(u)}{2^m m!} \qquad (6)$$

Equation 6 can be rearranged in the following form which is more adaptable for computation:

$$I(u)=\frac{\pi^2}{2}\sum_{k=0}^{\infty}(-1)^k A_k u^{-k}S_k(u) \qquad (7a)$$

where

$$A_k=\frac{\pi^{2k}}{2^k k!}\sum_{i=0}^{\infty}(-1)^i\frac{\pi^{2i}}{(2i+2k+2)(2i+1)!} \qquad (7b)$$

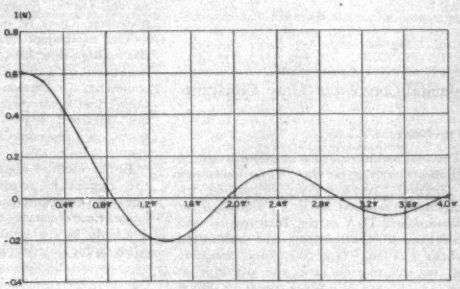


FIGURE 1

Figure 1 is a plot of $I(u)$ versus u for values of u from 0 to 4π, and is the work of Pranas Grusas.

References

1. "Theory of Bessel Functions," **G. N. Watson**, Cambridge University Press, second edition, 1948, p. 373.

2. "Tables of Functions," **E. Jahnke, F. Emde**, Dover Publications, fourth edition, 1945, p. 11.

3. "Tables of Spherical Bessel Functions," Columbia University Press, 1947.

Very truly yours,

DAVID K. CHENG

(Syracuse University, Electrical Engineering Department)

cable should be designed on the basis of the actual load cycle anticipated. It is in cases such as these, that Mr. Morello's comment assumes major importance.

(e) It is perfectly true that buried cables will often drop load before attaining steady-state temperature. This also happens to cables installed in ducts, when the temperature rise of the duct bank over the earth ambient is considered.

In the case of duct cable, it is usual to assume that only the temperature rise of the cable over the duct has attained steady state, and that the duct itself is at its winter ambient temperature, or a little above this, and not at its steady-state temperature. A corresponding assumption for a buried cable would probably be unduly conservative. However, if it is assumed, for purposes of calculation, that the ambient is about 10 C lower than it actually is, and that load is dropped from the steady state, a reasonably conservative design will result in this case also. This would appear to be a simple and conservative solution to the problem.

We regret that our closing discussion attributed to Mr. Morello an opinion that is actually ours; and we believe that his letter and our reply should clarify this situation.

Very truly yours,

F. H. BULLER (AM '25, M '29, F '53)
(Special Engineering Investigations, Analytical Engineering)

J. H. NEHER (AM '24, M '38)
(Philadelphia Electric Company)

Thermal Converter Time Constants

To the Editor:

The following statement constitutes a preliminary report on the "Time Constants of Thermal Converters for Indicating Instruments" prepared by F. L. Hermach for Subcommittee II-A of the Instruments and Measurement Committee, and submitted on May 1, 1956. It is considered desirable that this information be made available at once, in advance of a final report in which detailed data will be presented. Therefore, with Mr. Hermach's permission, I am submitting it in its present form.

Text of Statement

Specification of the time constant of a thermal converter is important in a number of applications of these devices. This is somewhat complicated because the change in emf of a converter after a step change in heater current is not strictly an exponential function of time. The departure from a simple exponential law of response results from various factors which control the flow of heat between the heater element and the thermocouple junction, as well as factors which influence the temperature rise of the heater element itself.

Discussions with various classes of users have indicated that most needs would be met by the specification of an arbitrarily designated "time constant," defined as the time required for 63 per cent of the change in emf of the thermocouple after a step change in heater current. For some applications the specification of an equally arbitrary "response time," defined as the time required for 90 per cent of the change in emf after a step change in current, may be more convenient.

Either of these quantities may be readily measured with a suitably calibrated oscillograph, provided with a stabilized d-c amplifier of appropriate sensitivity and amplification. A variety of oscillographs and of stabilized d-c amplifiers are commercially available for this purpose. Measurements with an accuracy of 5 per cent seem possible, and discussions to date indicate no real need for greater accuracy.

An alternative method of defining and measuring the time constant of a thermal converter has been proposed by R. W. Gilbert of the Weston Electrical Instrument Corporation. This time constant is defined as the "time integral delay of the element divided by the steady-state potential level" for the impressed step function $[1/e_0 \int (e_0 - e) dt]$. For converters having a short time constant (up to a few tenths of a second) a "bridge method" may be used to compare the transfer function against an R-C arm, R being adjusted to secure a steady-state null and C being the adjusted to produce a transient null when the bridge supply switch is operated. The null point is defined as the condition of zero integral at the balance detector, and the R-C product is the time constant of the converter. For converters having a long time constant, the direct integration of $\int e dt$ by suitable volt-second meters (commercially available as fluxmeters) may be more convenient.

The equivalent exponentials defined by the voltage-time integral and by the 63 per cent point on a direct oscillogram may differ somewhat in certain instances since their theoretical bases differ. However, the values obtained from preliminary measurements on a few converters agree within 5 per cent.

Either method appears to be feasible, but the apparatus required for voltage-time integral determinations in the range of longer time constants may not be as generally available as the equipment needed for oscillographic determination.

Yours,

FOREST K. HARRIS (AM '42, M '47)
Chairman
(Subcommittee on Indicating Instruments, Instruments and Measurement Committee)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question

RADIO AND ELECTRONIC COMPONENTS. Volume I: Fixed Resistors. By G. W. A. Dummer. Sir Isaac Pitman and Sons, Ltd., London, England, 1955. 187 pages, 5½ by 8¼ inches, bound. 28s. The design, manufacture, and usage of general purpose, high stability, and special types of fixed resistors are treated with information included on wattage, voltage, and pulse ratings, measurements, and future developments in design. British components of the types used by the armed services are specifically detailed, although mention is made of American and European types. Comparison charts showing characteristics of many types of resistors and a bibliography of some 350 references supplement the text. Future volumes in the series will deal with variable resistors, fixed and variable capacitors, and other common types of components.

RESISTANCE OF MATERIALS. By F. B. Seely and J. O. Smith. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., fourth edition, 1956. 459 pages, 5½ by 8½ inches, bound. $6.50. Part I of this standard text consists of the basic topics usually included in the subject: relations among loads, stresses, and deformations; stresses in beams; statically indeterminate members; dynamic loads, etc. Part II deals with such additional topics as composite beams, unsymmetrical bending, continuous beams, and elastic vibration of load-resisting members.

SAFETY MANAGEMENT. Accident Cost and Control. By R. H. Simonds and J. V. Grimaldi. Richard D. Irwin, Inc., Homewood, Ill., 1956. 555 pages, 6 by 9¼ inches, bound. $7.80. Of special interest to engineers are the chapters in this book dealing with the safety aspects of plant layout, machinery, boilers, electricity, materials handling, storage, new product development, and wastes disposal. As a whole, the book is a comprehensive treatment of principles, supplemented by numerous practical suggestions and illustrated by selected case histories. Among the major topics treated are organization of a safety department, accident cost analysis, health hazards, protective equipment, and employee selection and training. Appendixes list common industrial health hazards and give properties of selected flammable materials.

TABLE OF HYPERBOLIC SINES AND COSINES. ($x=2$ to $x=10$). Applied Mathematics Series, National Bureau of Standards, No. 45, 1955. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 81 pages, 7½ by 10½ inches, paper. 55¢. This table provides values of hyperbolic functions in the range from $x=2$ to $x=10$ at intervals of 0.001 to nine significant figures. It supplements previously published tables which covered the range 0 to 2 at intervals of 0.0001 and the range 0 to 10 at intervals of 0.1.

TABLE OF THE DESCENDING EXPONENTIAL. ($x=2.5$ to $x=10$). Applied Mathematics Series, National Bureau of Standards, No. 46, 1955. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 76 pages, 7½ by 10½ inches, paper. 50¢. In an earlier set of tables (1939) the descending or negative exponential e^{-x} was tabulated from $x=0$ to $x=2.5$ at intervals of 0.0001, and for the range $x=1$ to $x=100$ at intervals of 1.0. The present table gives values in the range $x=2.5$ to $x=10$ at intervals of 0.001, to 20 decimal places.

TASCHENBUCH DER HOCHFREQUENZTECHNIK: Edited by H. Meinke and F. W. Grundlach. Springer-Verlag, Berlin, Germany, 1956. 1408 pages, 5½ by 8 inches, bound. DM 69. A comprehensive handbook on high-frequency engineering containing an extensive compilation of curves, formulas, and basic data with special reference to communications applications. Theory, design, and operating characteristics are presented in the 25 sections written by authorities in the special fields. Electronics applications other than in communications are not included. A detailed table of contents and an extensive subject index are provided.

THE THEORY OF LINEAR ANTENNAS. By R. W. P. King. Harvard University Press, Cambridge, Mass., 1956. 944 pages, 6½ by 10¼ inches, bound, $20. This treatise is an advanced analytical study of electromagnetic radiation, transmission, reception, and scattering as related to antennas made from cylindrical conductors of relatively small cross section. It covers comprehensively and systematically both theoretical and experimental aspects of the subject and includes, as the subtitle indicates, extensive charts and tables for practical applications. Detailed treatment is given to the linear radiator as a circuit element, circuit properties of arrays of antennas, the receiving antenna as a circuit element, electromagnetic fields of antennas, the field of linear antennas over conducting earth, and the antenna as a boundary value problem. A 12-page bibliography and tables of generalized sine and cosine integrals are included.

WORLD SYMPOSIUM ON APPLIED SOLAR ENERGY, PROCEEDINGS. (NOVEMBER 1955). Published 1956 by Stanford Research Institute. 304 pages, 8½ by 11½ inches, bound. Available from Association for Applied Solar Energy, 204 Heard Building, Phoenix, Ariz. $5. The 19 technical papers included in these proceedings deal with such subjects as solar machines and stills, high temperature furnaces, the heat pump, water heaters, cooling with solar energy, algae culture, electricity from the sun, and residential uses of solar energy. The proceedings also include a panel discussion on solar house heating and two round-table discussions devoted to the architectural problem of solar collutors and the future of applied solar energy.

ASTE ANNUAL COLLECTED PAPERS 1956. Published by American Society of Tool Engineers (ASTE), 10700 Puritan Avenue, Detroit 38, Mich. Various pagings, 8½ by 11 inches, loose-leaf manual. $7.50. Ceramic tooling, drawing of titanium, applications of diamond tools, equipment replacement, computers for machine tool control, training and development of engineers, automation, and a wide range of additional subjects are covered in the 51 papers included. The volume also contains a panel discussion on carbide die problems, research reports on cemented borides and methods of applying cutting fluids, and a summary of a recent ASTE survey on the impact of automation on production in the immediate future. Many of the papers are fully illustrated, and some include lists of references.

COMMON SENSE IN RESEARCH AND DEVELOPMENT MANAGEMENT. By G. W. Howard. Vantage Press, 120 West 31st Street, New York 1, N. Y., 1955. 104 pages, 5½ by 8¼ inches, bound. $2.75. This is an impartial description of current practice, based on visits to industry, government, and university research establishments in the United States, Canada, and Europe. The activities described include organization; selection and professional development of personnel; duties of the director; planning and checking progress; internal communications; and technical services—library, laboratory, stenographic, etc. A 10-page annotated bibliography is included.

DYNAMICS OF MACHINERY. By J. B. Hartman. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1956. 283 pages, 6 by 9¼ inches, bound. $7.50. Emphasizing the development of the ability to apply fundamental principles to the solution of problems of machine design and analysis, this book deals with such selected topics as mechanical vibrations, balancing of machinery, engine dynamics, mechanical transients, and the dynamics of automatic control systems. Vector analysis, Fourier series, La Place transforms, and other mathematical techniques not usually encountered in undergraduate courses are introduced as needed. Problems are provided at the end of each chapter, and a set of special projects designed to develop a professional approach to engineering problems is contained in an appendix.

ENGINEERING IN HISTORY. By R. S. Kirby, S. Withington, A. B. Darling, F. G. Kilgour. McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., 1956. 330 pages, 6 by 9¼ inches, bound. $8.50. This is a general introduction to the subject, devoted to recording the most significant achievements in certain branches of civil, mechanical, electrical, and metallurgical engineering. Engineering history is integrated into general history with the intent of showing how social conditions influenced engineering advances and how these in turn influenced the development of Western civilization. Selected references are listed after each chapter, and a general bibliography is given at the end of the book.

FREQUENCY RESPONSE. Edited by Rufus Oldenburger. The MacMillan Company, 60 Fifth Avenue, New York 11, N. Y., 1956. 372 pages, 8¼ by 11¼ inches, bound. $7.50. This is a compilation of papers intended to cover a wide range of interests, from those of the beginner with little mathematical training to those of the expert. The papers, consisting of all those presented at the 1953 American Society of Mechanical Engineers Symposium on Frequency Response, plus 10 others, are grouped under the following headings: fundamentals; aids; servo, airplane, and power system applications; process control; transient response; optimum controls; nonlinear techniques; sampling controls; and statistical methods. The volume is indexed by authors and subjects, and a bibliography is included.

HISTORY OF AMERICAN TECHNOLOGY. By J. W. Oliver. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1956. 676 pages, 5½ by 9¼ inches, bound. $6.50. This is a comprehensive account of the status and development of the various areas of technology—mining, manufacture, transportation, communication, etc.—during each of the four historical periods into which the book is divided: pre-Revolutionary, Revolution to Civil War, Civil War to 1900, and 1900 to the present. Stressed throughout is the influence of technological progress on the economic and political growth of the United States and on American civilization as a whole.

INDEX MATHEMATISCHER TAFELWERKE UND TABELLEN. Compiled by Karl Schütte. Verlag R. Oldenbourg, Munich, Germany, 1955. 143 pages, 5½ by 8½ inches, bound. DM 14.50. This is a list of about 1,200 tables, giving only authors, titles, as well as place and date of publication. It is a guide to tables for practical and numerical calculating, logarithms of circular functions, natural values of circular functions, elliptic functions, integrals, and other purely mathematical tables, as well as to tables from other branches of science such as physics, chemistry, astronomy, geodesy, geophysics, and meteorology. Chapter headings and subdivisions of chapters are given in both German and English.

LEGAL PROBLEMS IN ENGINEERING. By Melvin Nord. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 391 pages, 6 by 9¼ inches, bound. $7.50. The section of this book devoted specifically to engineering-legal problems covers construction contracts and specifications; governmental regulation of business; patents, copyrights, and trademarks; and air and stream pollution. In addition, the book includes a section dealing with engineering ethics and professional registration, and another explaining the legal principles involved in contracts in general, sales, insurance, workmen's compensation, partnerships, municipal corporations, and other subjects of interest to engineers. Cases used to illustrate the discussion are given in condensed form and simplified language.

LEHRBUCH DER BERGWERKSMASCHINEN. (Kraft und Arbeitsmaschinen). By C. Hoffmann. Springer-Verlag, Berlin, Germany, fifth edition, 1956. 534 pages, 7¾ by 10¾ inches, bound. DM 36. A comprehensive, basic treatise on the generation, transmission, and utilization of power in mining operations. It covers steam boilers and engines, pumps, conveyers, underground mining machinery, loading machines, air-conditioning machinery, compressors, and compressed-air equipment. The new edition of this standard work has been considerably enlarged and brought up to date.

LEHRBUCK DER DRAHTLOSEN NACHRICHTENTECHNIK. Volume II. Antennen und Ausbreitung. By K. Fränz and H. Lassen. Springer-Verlag, Berlin, Germany, second edition, 1956. 332 pages, 6¾ by 10 inches, bound. DM 45. This second volume of a "Textbook on Radiocommunication" covers the following topics: general theory of wave propagation; wave propagation at various frequencies; ionosphere research; atmospheric and extra-terrestrial disturbances; and radiation and reception of electromagnetic waves, dealing with various types of simple and special antennas. There is a considerable bibliography, and the new edition has been revised to cover recent developments.

THE MEANING OF RELATIVITY. Fifth edition, including the Relativistic Theory of the Nonsymmetric Field. By Albert Einstein. Princeton University Press, Princeton N. J., 1955. 167 pages, 5¾ by 8 inches, bound. $3.75. Shortly before his death, Mr. Einstein completed a revised version of his "Generalized Theory of Gravitation" in which he felt he had succeeded "...in simplifying the derivations as well as the form of the field equations..." This simplified version is now presented for the first time as Appendix II, along with the original content of the earlier editions.

PRODUCTION CONTROL. Text and Cases By William Voris. Richard D. Irwin, Inc., Homewood, Ill., 1956. 413 pages, 6 by 9¼ inches, bound. $7.20. This is a presentation of basic principles and their applications in intermittent and continuous manufacturing, with considerable emphasis on company organization and on the interrelationships between production control and other manufacturing functions. Control in a small company is treated separately, and material is included on the automatic factory, computers, operations research, and linear programming. Case problems from actual companies are used to illustrate the discussion.

PROPAGATION DES ONDES DANS LES MILIEUX PÉRIODIQUES. By L. Brillouin and M. Parodi. Masson et Cie., Paris, France, 1956. 347 pages, 6¾ by 9¾ inches, bound. F frs. 4600. This treatise on wave mechanics deals with a variety of problems of varying physical origin but for which the mathematical treatment leads to equations with common characteristics and similar solutions. It develops the theory from simple 1-dimensional conditions to 2 and 3-dimensional states. The illustrative situations are to a large extent electrical and electronic in nature: electric lines and filters, wave guides, etc., but the fields of mechanical vibrations, crystallography, and the physics of the solid state are also represented.

DIE LAPLACE-TRANSFORMATION UND IHRE ANWENDUNG IN DER REGELUNGSTECHNIK. Edited by R. Herschel. Verlag R. Oldenbourg, Munich Germany, 1955. 142 pages, 6 by 9¼ inches, bound. DM 12. The importance of the Laplace transformation in the field of feedback engineering is demonstrated by this group of papers. Several applications are treated in detail following the introductory discussions. The final paper deals with the treatment of control circuits by communication engineering methods.

NATIONAL ELECTRONICS CONFERENCE PROCEEDINGS. Volume XI. Published by the National Electronics Conference, Inc., 84 East Randolph Street, Chicago, Ill., 1955. 1,040 pages, 6 by 9¼ inches, bound. $5. The 102 technical papers contained in this volume cover specific aspects of such subjects as antennas, acoustics, magnetic amplifiers, microwave tubes, circuit analysis, wave guides, servomechanisms, etc. Two groups of invited papers included were delivered at special symposiums devoted to solid-state electronics and to radio astronomy. Lists of references accompany most of the papers.

PHYSICS OF FIBRES. By H. J. Woods. The Institute of Physics, London, England, 1955. 100 pages, 9¼ by 5½ inches, bound. $4.50. Chiefly concerned with the fundamental physical techniques for the study of the structure and properties of natural fibers, this book deals with X-ray diffraction investigations, optical properties, elastic properties, and the electron microscopy of fibers. Two chapters are devoted to structure in general and to dimension, form, and general properties. A bibliography and a list of references by chapters are included.

PROCEEDINGS OF THE SEVENTH BRITISH ELECTRICAL POWER CONVENTION 1955. Available from the Secretary, British Electrical Power Convention, London, England. 524 pages, 5½ by 8¼ inches, bound. 12s 6d. The major part of these proceedings consists of eight papers. The first paper, a forecast of the electrical industry in Britain for the next 10 years, includes a discussion of the part nuclear power plants will play in supplying electricity. Three of the other papers deal with career opportunities in the industry, and the remaining papers discuss present and future uses of electric power in the steel, coal and chemical industries, and in restaurants and allied enterprises.

THE RADIO AMATEUR'S HANDBOOK. American Radio Relay League, West Hartford, Conn. 33rd edition, 1956. Various pagings, 6½ by 9½ inches, paper. $3. A new edition of a standard handbook covering the entire field, from basic theory to practical construction details. Changes have been made throughout to take note of recent changes in practice, a new chapter has been added on semiconductors, and a considerable amount of new apparatus is described in the chapter on measurement. This edition also includes design data and construction information on vhf beam antennas.

RELIABILITY FACTORS FOR GROUND ELECTRONIC EQUIPMENT. Edited by Keith Henney as editor-in-chief. McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., 1956. Various pagings, 8½ by 11½ inches, bound. $7.50. A summary of the results of investigations by a number of Government and private agencies on the reliability of military electronic equipment. The topics treated include the reasons for malfunctioning of equipment; statistical methods of approaching unreliability; electrical, electronic, and environmental factors; human engineering; principles governing the selection of components; and problems of interference by other equipment. Also included are chapters on the implications of automatic production for equipment design, the preparation of manuals, and maintenance. Many of the proposed techniques for improving reliability are applicable to industrial as well as military equipment design.

SCATTERING AND DIFFRACTION OF RADIO WAVES. By J. R. Mentzer. Pergamon Press, Inc., 122 East 55th Street, New York 22, N. Y., 1955. 134 pages, 5¾ by 8⅝ inches, bound. $4.50. Emphasizing mainly aspects of the subject of interest for radar, this monograph deals with the mathematical formulation of problems by differential equations, integral equations, and approximate methods; the solution of two and three-dimensional problems; and the measurement of radar cross sections. Specific topics considered include scattering by finite cylinders, diffraction by small apertures, tensor treatment of scattering by curved surfaces, and the vector variational principle for scattering. A table of radar cross-section formulas is given in an appendix.

THERMAL POWER FROM NUCLEAR REACTORS. By A. S. Thompson and O. E. Rodgers. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 229 pages, 9 by 5¾ inches, bound. $7.25. A discussion, from the mechanical engineer's viewpoint, of the engineering design problems involved in the generation of heat in reactors, the removal of heat from reactors, and the use of the heat in thermal power plants. Considerable space is devoted to calculations of neutron distribution, criticality, and reactor kinetics. Problems of shielding, materials, thermal stress, and heat transfer are also treated. The use of numerical methods and dimensional analysis for the solution of design problems is emphasized.

CONTROL OF NUCLEAR REACTORS AND POWER PLANTS. By M. A. Schultz. McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., 1955. 313 pages, 6 by 9¼ inches, bound $7.50. Basic techniques for the control of solid fuel heterogeneous reactors are presented in this book in engineering terms and in such a manner that control systems for other types may be designed by extension of the methods treated. The first part of the book covers the physics of reactor control, the response of a reactor to various types of driving functions, derivation of the transfer function, and the reactor control-loop and its response to transient disturbances. Later chapters deal with control requirements and present practices, basic problems of plant response and programming, radiation detectors, and control of plants in startup, operation, and shutdown. The last chapter discusses simulators for the solution of reactor plant problems.

ELECTRIC GENERATION: HYDRO, DIESEL AND GAS TURBINE STATIONS. By Bernhardt G. A. Skrotzki. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1956. 458 pages, 6 by 9¼ inches, bound. $8.50. One of a series of four volumes comprising the Electric Utility Library, a practical series providing a comprehensive introduction to the electric power industry. The two-thirds of the volume devoted to hydro stations deals with precipitation runoff and related topics; dams, penstocks, tunnels, and other accessories; generators, transformers, buses, switches, and other equipment; and problems of operation and maintenance. One chapter is devoted to gas turbine systems and the rest of the book to the various types of oil and gas burning reciprocating engines and their stations.

ELECTRICAL CIRCUITS: DIRECT AND ALTERNATING CURRENT. By C. S. Siskind. McGraw-Hill Book Company, 330 West 42nd St., New York 36, N. Y., 1956. 516 pages, 6 by 9¼ inches, bound. $6.75. A basic text on the fundamentals of electric, magnetic, and dielectric circuits prepared to furnish the necessary background for the study of electrical machines and systems. The book is divided into two parts: part one covering direct current circuits, magnetism, d-c instruments, inductance, capacitance, and dielectric circuits; part two (devoted to alternating current circuits) dealing with sinusoidal voltages and currents, resistance, inductance, and capacitance circuits, circuit analysis by vector loci, network laws, polyphase circuits, and other subjects. Given in an appendix are mathematical derivations in which basic equations are developed by the use of differential and integral calculus.

ELECTRONIC COMPUTERS AND MANAGEMENT CONTROL. By George Kozmetsky and Paul Kircher. McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., 256 pages, 6 by 9¼ inches, bound. $5. Written in nontechnical language for business executives, this book explains how computers operate, shows how they can be applied to such functions as accounting, production scheduling, or cost control, and gives information on input, processing, storage, control, and output. It deals also with the basic concepts of scientific methods for analyzing business data for management planning and control, and with the tools of the analyst—linear programming, calculus of variations, information theory, stochastic models, etc. An appendix gives specific details of currently available commercial equipment.

ELECTRONIC DATA PROCESSING FOR BUSINESS AND INDUSTRY. By R. G. Canning. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., 1956. 332 pages, 5½ by 9¼ inches, bound. $7. The purpose of this book is to inform management about the nature of digital data processing devices and to explain how they may be applied to clerical operations Treated in detail are characteristics of major electronic components, methods of instructing machines, the systems engineering approach to determining company needs, the design of data processing systems to meet specific requirements, and planning for an intermediate program. Such applications as unit control in a department store and production control in a manufacturing plant are analyzed, and systems for these operations are outlined.

HALBLEITERPROBLEME. Edited by Walter Schottky. Friedr, Vieweg & Sohn, Braunschweig, Germany, 1954. 387 pages, 222 pages, 9½ by 6¼ inches, bound. DM 28.80 each. These two volumes contain 28 specialized articles on various aspects of semiconductor properties and effects, including discussions of polar crystals, electron interactions and transitions, electrolytic rectifiers, selenium and copper oxide rectifiers, transistor characteristics, photoconductivity, and metal electrodes with nonmetallic surface layers. The articles are mainly in German, with English summaries.

IMPULSTECHNIK. Edited by F. Winckel. Springer-Verlag, Berlin, Germany, 1956. 346 pages, 6 by 9¼ inches, bound. DM 37.50. This series of lectures on pulse technique presented at the Technical University of Berlin covers theoretical aspects as well as practical presentations of methods and circuits for the generation, modulation, synchronization, and transformation of simple and composite pulses. Applications to various special fields—radio navigation, electronic calculators, etc.—are dealt with separately. One particular omission is the application to feedback engineering which is considered to have been effectively covered in other books.

INSTALLATIONS ÉLECTRIQUES À HAUTE ET BASSE TENSION. Volume I. By A. Mauduit. Dunod, Paris, France, third edition, 1956. 463 pages, 6 by 9¼ inches, bound. F fr. 3600. First volume of a comprehensive series on electrical installations of both high and low tension. Deals principally with electric lines: the physical and electrical characteristics of high-voltage underground cables; characteristics and electrical design of overhead lines; faults in electric lines and networks, including the dangers and precautions to be taken. The properties of gaseous, liquid, and solid dielectrics and other fundamental aspects are covered in the first section.

IONIZED GASES. By A. von Engel. Clarendon Press, Oxford, England, 1955. 281 pages, 6 by 9¼ inches, bound. Available from Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. $6.75. The chief topics dealt with are processes for producing ions and electrons in gases, mobility, charge transfer, diffusion, mutual repulsion, recombination, glow discharge, ionization in an electric field, and arc discharge. Intended as an introduction to the study of electric discharge in gases for students, research workers, and engineers, the book places emphasis on a physical understanding of the mechanism but includes some of the theory. References to more advanced treatments of specific topics are supplied.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

The Heating-Ventilating-Air-Conditioning Guide 1956. In the 1956 Guide, chapters are substantially changed, with attention given to the presentation of heat transmission coefficients of building materials. Design values for conductivity and conductance are included for many more materials than in any other previous Guides. More tables make it easy to compute the effect of adding air spaces or insulations to walls, ceilings or floors. The technical data is presented in seven sections as follows: I. Fundamentals, II. Human Reactions, III. Heating and Cooling Loads, IV. Combustion and Consumption of Fuels, V. Systems and Equipment, VI. Special Systems, and VII. Instruments and Codes. The technical data section of this 34th edition contains 1,176 pages. The catalogue data section presents material concerning the products of 335 manufacturers. $12. Order from the American Society of Heating and Air-Conditioning Engineers, 62 Worth Street, New York 13, N. Y.

Safety Management. By R. H. Simonds and J. V. Grimaldi. A comprehensive survey of safety management with suggestions and procedures presented in book form for the first time. Particularly useful is the section on accident cost analysis in which recently developed method of estimating uninsured costs, replacing the old 4 to 1 ratio, is fully explained, together with supporting statistical data and suggestions for using cost figures in securing management backing for safety programs. New ideas are offered on motivating safety and locating hazards. Safety problems in connection with the manufacturing and marketing of new products are given treatment hitherto lacking. Added emphasis is placed upon preparation for the control of catastrophes. Suggestions are made for the disposal of liquid, gaseous, and operational wastes. Appendixes list common industrial hazards, their occurrence and properties, and properties of selected flammable materials. 568 pages. $7.80. Available from Richard D. Irwin, Inc., Homewood, Ill.

Techniques for Application of Electron Tubes in Military Equipment. A revised edition by R. S. Whitlock, Wright Air Development Center, U. S. Air Force. Part I discusses the properties common to all electron tubes. Part II considers the effect of these properties in circuit design. Part III presents a summary of application information with reference to specific structural or functional categories of tubes. This is followed by mechanical, electrical, and environmental information on specific tube types together with any application notes which are uniquely applicable to specific tube types. Part IV outlines observed property behavior on specific tube types. 295 pages. $5. May be ordered from Office of Technical Service, U. S. Department of Commerce, Washington 25, D. C.

Government-Industry Co-operation in Standardization. Addresses by Government and industrial leaders and military officials at the Sixth National Conference on Standards, Washington, D. C., sponsored by the American Standards Association and the National Bureau of Standards. Addresses 30 in number point out the effectiveness of standards in saving money and increasing efficiency. Major segments of industry, Federal, and state governments and the three military services are represented in the standards programs presented. 94 pages, 8 photographs. $3. May be obtained from

the American Standards Association, 70 East 45th Street, New York 17, N. Y.

Home Lighting Ideas for Kitchens and Bathrooms. Includes room and lighting layouts for typical kitchen and bathroom arrangements, remodeled as well as newly constructed, with complete instructions and installation data for the lighting systems. Among the latest types of lighting shown are recessed soffits and coves, louverall and luminous ceilings (particularly adaptable to the comparatively small areas of these rooms) as well as standard fluorescent and incandescent fixtures. Ten different rooms are covered including dimensions and floor layouts for each, with all necessary information concerning the name of manufacturer and catalog number of fixtures employed, wattage and color of lamps, and construction details. 50¢. Copies may be obtained from Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy. The latest available volumes in this series are Vol. IV, "Cross Sections Important to Reactor Design," containing 357 pages; Vol. VII, "Nuclear Chemistry and the Effects of Irradiation," 691 pages; Vol. XV, "Applications of Radioactive Isotopes and Fission Products in Research and Industry," 327 pages; and Vol. XVI, "Record of the Conference," 203 pages. What makes Vol. IV important is that it contains measurements of the probability for given nuclear reactions (cross sections) that were closely guarded secrets in many countries prior to the Atomic Energy Conference held in Geneva last August. Vol. VII is devoted to the fundamentals on which chemical processes and irradiation experience are based. The two ways in which radioactive materials are used are illustrated by many examples in Volume XV. Included in Volume XVI are a brief history of the Conference; the record of the opening and closing sessions, including the Presidential addresses on the range and importance of the Conference and discussion on international co-operation in the peaceful uses of atomic energy; a list of Conference delegates; the Conference program, which in essence forms a subject index to the entire set of volumes; a numerical index of papers; and a complete author index. Vol. IV and Vol. XV, each $7.50; Vol. VII, $10; Vol. XVI, $5. A total of 16 volumes of the Proceedings will be issued. They will contain all of the papers and verbatim records of the International Conference. So far, in addition to the aforementioned volumes, Volumes II, III, and XIV have been published. The price for the complete set has been set at $130. Orders can be placed through the UN Bookshop, or Sales and Circulation Section, United Nations, New York, N. Y.

Automatic Record Changer Service Manual. Vol. 7 of the Changer Manual Series contains complete service data of 7 record changers and 12 tape recorders produced during 1954 and 1955. For record changers, complete descriptions of the change cycles and suggested remedies for correcting any malfunctions are presented. Schematics, parts lists, replacement parts data, and trouble shooting procedures are presented for tape recorders. A cumulative index showing model coverage in all volumes is included in order to enable quick reference to applicable service data. A cross-reference that shows which basic changer mechanism was used in a particular receiver is also included. 288 pages. $3. Available from Howard W. Sams and Company, Inc., 2201 East 46th Street, Indianapolis 5, Ind.

The Radio Amateur's Handbook, 33rd Edition—1956. By the Headquarters staff of the American Radio Relay League. The standard manual of amateur radio communication, revised and restyled in the light of current needs as a radio construction manual, reference work, and training text for class or home study. Principal additions to the very-high-frequency sections of the handbook are a series of simple converters to be used with a standard communications receiver, and condensed design data as well as practical construction information on vhf beam antennas. An enlarged basic theory section includes a chapter on semiconductors, in consonance with their growing importance. The chapter on measurements contains a considerable amount of new apparatus, and the data chapter on vacuum tubes and semiconductors lists all useful types. 760 pages, including catalog section and 13 page index. It contains over 1,350 illustrations, including 95 charts and tables, and 571 tube-base diagrams, and 122 basic formulae. $3 in the United States, $3.50 in U. S. Possessions and Canada, $4.00 elsewhere. Copies may be ordered from American Radio Relay League Inc., West Hartford 7, Conn.

Transistors I. This volume contains 31 papers which have not been published elsewhere. In order to round out the presentation and increase the utility of the book, 10 papers which have appeared in various periodicals are also included. In addition, abstracts of 46 other RCA papers on the subject of transistors are included. The book is arranged in six sections: General, Materials and Techniques, Devices, Fluctuation Noise, Test and Measurement Equipment, and Applications. 676 pages. $4.50 in the United States and its possessions, $4.70 elsewhere. Orders may be sent to Radio Corporation of America Laboratories, David Sarnoff Research Center, Princeton, N. J.

Data and Decision: Using Electronic Computers in Business. How business management can improve its decisions with the aid of electronics is described in a series of four 35-mm color sound filmstrips released by the American Management Association, national management educational organization. The filmstrip series is the first training film on electronic data processing that covers the complete field—evolution, definition, machine function, methods and applications, effect on personnel policy and company planning, and future developments. Intended for orientation of top management, financial executives, and clerical and nonclerical employees in the elements of electronic data processing, this series deals with the development and business application of the electronic digital computer. Each of the four filmstrips in the series is designed as a self-contained unit. Together they constitute a complete, nontechnical training program in electronic data processing, explaining how the computer evolved, how it works, how to plan it, and how to use it. The four filmstrips are sold as a set. Companies and other interested groups may order prints, accompanied by sound recordings and a manual containing scripts and other material for conducting training programs, from Visual Education Department, American Management Association, 1515 Broadway, Times Square, New York 36, N. Y.

European Technical Digests. The best articles from European technical and industrial journals, translated and digested, are now available monthly to American industry. Many of the articles in the periodical, which averages 140 illustrated pages, discuss new products and processes developed by European manufacturers. The magazine contains digests of only the most effective articles gleaned by specialists from over 1,000 European periodicals. Almost all fields of industrial interest are covered: ceramics and glass; chemicals; corrosion, protective coatings, and finishing processes; electrical engineering and equipment; food and allied products; fuel, power, and lubricants; leather; materials handling; metallurgy, metal working, and machine shop; packaging and packing; safety; structural engineering and building; textiles; timber and wood; transport; and many others. Subscriptions may be obtained from the Organization for European Economic Co-operation Mission Publications Office, 2000 P Street, N. W., Washington 6, D. C. The rates are $24 a year or $2.50 per single issue.

Hi-Fi Loudspeakers and Enclosures. This booklet is divided into three main sections: "The Loudspeaker," "The Enclosure," and "The Room." The first section covers the basic principles of speakers along with multispeaker design with full information on crossover networks, and charts and graphs which permit the hobbyist to construct his own networks. The second section analyzes types of loudspeaker baffles from the simple flat baffle to the most complex folded horn enclosures. Again, constructional details are included. The acoustical properties of rooms are covered in the last section including data on enclosure placement and room treatment. An appendix has 18 complete plans for the construction of typical loudspeaker enclosures of all types of various speaker sizes. 368 pages. $4.60. Order from John F. Rider Publisher, Inc., 480 Canal St., New York 13, N. Y.

Preferred Circuits. Navy Aeronautical Equipment, *NAVAER 16–1–519*, by J. H. Muncy. This one-volume loose-leaf handbook, made available by the National Bureau of Standards and the Navy Bureau of Aeronautics, is comprised of two parts: the Preferred Circuits Manual and Notes to the Preferred Circuits Manual. The Manual presents 32 preferred circuits, including voltage regulators, multivibrators, blocking oscillators, video detectors, and amplifiers.

Schematics of each circuit are provided, with characteristics and other information, permitting ready selection and construction; successive pages explain use and design methods. The preferred circuits were derived after experimental measurements had been made on a large number of examples taken from both commercial and military electronic equipment. The notes explain the steps which led to selection and design of each preferred circuit. The handbook has been published for distribution to promote standardization of electronic circuits. Its main purpose is to encourage voluntary reduction of unnecessary circuit variations in military equipment. If partial standardization of electronic circuits is achieved, substantial economies will be realized. For the manufacturer, standardization will result in lower production costs, quicker shifting from development to production, lower parts inventories, simplification of mechanized production, and conservation of engineering manpower. For the military services, standardization will result in lower procurement costs, simpler maintenance training, shorter lead time on delivery of equipment, fewer spare parts at field installations, and greater operational reliability. $1.75, Government Printing Office, Washington 25, D. C.

Instantaneous Sound Spectrograph. A report of the development by the naval research Laboratory of a sound spectrograph which presents an instantaneous plot of the energy of an audio signal. A permanent graphic recording of the spectral analysis is made on a new type of chemically treated electrosensitive paper. The time dimension is plotted along the length of the paper, the frequency is plotted across the width, and the energy of individual frequency components is indicated by the density of the recorded marks. The spectral analysis is performed by a group of 42 comb-type bandpass filters. These filters are of a passive LC design and are both accurate and stable with respect to their frequency selectivity characteristics. This report, *PB111864*, by R. D. Misner, is available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., price $1. 35 pages, illustrated.

Industrial Research Laboratories of the United States (1956). The tenth edition of an annotated directory that has been compiled and published by the National Academy of Sciences–National Research Council at intervals since 1920. The 1956 edition includes information on 4,834 laboratories of 4,060 companies gathered during the first half of 1955. The entry for each organization reported shows the names and locations of its laboratories, its principal research executives, the number of professional, technical, and administrative employees in each laboratory as well as the kinds of research in which they are engaged. In addition, as an aid in finding individual laboratories or subsidiaries of large companies, an effort has been made to report the entire structure of an organization under its parent company's name with extensive cross-references to component units, subsidiaries, and laboratories. A simple alphabetical code indicates the types of research services performed by each laboratory, showing whether it undertakes research only for its parent company or sponsor or whether it also does fee or contract research for others, whether it offers consultation or advice, and whether it does testing and analysis. The code also indicates the kind of sponsorship under which each laboratory operates, i.e., whether it is owned by a commercial organization, by a nonprofit research institute, by a trade association, or is an independent commercial laboratory. Government and university research and development laboratories are not included. An index of research activities includes well over 1,000 major subject headings. A 10-page index of the geographical location of the laboratories is also included. 560 pages. $10. Order from the Publications Office, National Academy of Sciences–National Research Council, 2101 Constitution Ave., Washington 25, D. C.

Radioisotopes in Medicine. The complete proceedings of a special course on the subject, which was conducted by the Oak Ridge Institute of Nuclear Studies (ORINS) in September 1953. The book, issued by the US Atomic Energy Commission, contains 48 chapters, divided into nine main sections, complete with bibliography, index, charts, and illustrations. Editors are G. A. Andrews, Marshall Brucer, and E. B. Anderson of the ORINS Medical Division. Contents of the book include papers concerning availability and uses of isotopes; problems in radiation, radiation measurement, and dosimetry; tumor localization; diagnostic and therapeutic uses of radioiodine; metabolic and vascular studies; isotopes in the study and treatment of hematologic disorders; therapy with radioactive colloids; and therapy with external and implanted sources. 817 pages. $5.50. Order from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Proceedings of the World Symposium on Applied Solar Energy. The full proceedings of the Symposium held in Phoenix, Ariz., November 1–5, 1955, presents papers by 30 internationally recognized authorities on solar energy utilization. Photographs and drawings illustrate papers on solar furnaces, flat-plate collector applications, algal culture, electrical energy conversion, and architectural design. The book is introduced by a 7-page picture section covering the various sessions and the Solar Engineering Exhibit held in conjunction with the Symposium. The final section contains a summary of a round-table discussion on "The Future of Applied Solar Energy." 300 pages. $5. Available from the Association for Applied Solar Energy, 204 Heard Building, Phoenix, Ariz.

NEMA Electric Heating Manual. A guide for use in planning the installation of residential electric heating equipment and in estimating operational costs of such equipment, produced by the Electric House Heating Equipment Section of the National Electrical Manufacturers Association (NEMA). The manual contains the following: recommendations on amount of insulation for electrically heated homes, a standard method for computing heat loss, a method of selecting the proper size of electric heating equipment, and a formula for estimating the annual operating costs for electric heating installations. As contrasted to the Btu method used in heating manuals for other fuels, this manual is expressed in watts. It contains maps and tables so that the calculations can be made for each area of the United States. A calculation on a sample home is included illustrating how the manual can be utilized. 25¢. Available from NEMA, 155 E. 44th Street, New York 17, N. Y.

Work Simplification on Film. A folder listing 38 films on the use of work simplification in industry, explaining the terms by which the 16-mm films are available for rental. These films, produced by leading American companies, all have won awards in the annual Methods Improvement Competition sponsored by the Industrial Management Society. Many of the films are in color and sound. The films are approximately 10- to 15-minutes in running time and show "before" and "after" operations of work simplification projects, in both plant and office operations. 12 pages. Copies are available free from the Industrial Management Society, 35 East Wacker Drive, Chicago 1, Ill.

Zirconium—Technology and Economics. A report based on the proceedings of a two-day Atomic Industrial Forum meeting held under the sponsorship of the Subcommittee on Process Metallurgy and Fabrication of the Forum's Industrial Committee on Reactor Materials. It includes papers and discussion on chemistry and production of metallic zirconium, fabrication, properties, corrosion behavior, alloys, supply of raw and refined materials, commercial products available, future Atomic Energy Commission and industrial requirements. Publication price is $3 per copy. Further information may be obtained from Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16, N. Y.

Copper Wire Tables. Fourth edition, National Bureau of Standards Circular 31. These tables are of special importance to workers in the copper industry, electrical engineering, and related fields concerned with the distribution of electric power. Copper wiring is used almost universally for such distribution. The first edition of this circular was prepared in 1912 at the request of the Standards Committee of the AIEE. It was an attempt to standardize the characteristics of a number of different wire gauges in use at that time. All data are expressed in both English and metric units. The American Wire Gage as presented in this publication is formed by geometrical progression. The circular also contains a number of very simple formulas for computing data for any size wire. In the new revision the tables have been extended to 50 gage and up to 200 C to make them more useful to the present demands of science and industry. 2 line cuts, 19 tables. 30¢. Order from the Government Printing Office, Washington 25, D. C.

what is grey matter worth?

For the engineer or scientist who has enough to make him different, *grey matter* is worth a rewarding life of creative achievement in a working climate where ideas are King...and the benefits measure up to the man and his mind.

For 56 years Firestone has grown on *grey matter*—in Research, Development and Production. Now, simply, we need additional *grey matter* for such Firestone "firsts" as the "Corporal" surface-to-surface ballistic missile. Here are just a few of the Engineering activities in which Firestone needs more *grey matter:*

Electronics Systems
Mechanical Systems
Propulsion Components
Flight Simulation
Mechanical Structures and Dynamics
Stress Analysis
Metallurgical Lab

If you're the man with extra *grey matter* who wants the chance to really use it, write us today. We'll put you in touch with a Firestone man who has your kind of *grey matter*, too.

Firestone

GUIDED MISSILE DIVISION

RESEARCH • DEVELOPMENT • MANUFACTURE

"Find your Future at Firestone"—Los Angeles • Monterey

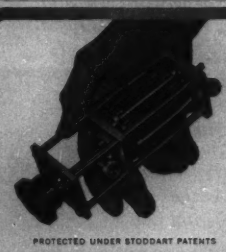
WRITE: SCIENTIFIC STAFF DIRECTOR, LOS ANGELES 54, CALIF.

PRECISION ATTENUATION to 3000 mc!

SINGLE *"in-the-line"* ATTENUATOR PADS *and* 50 ohm COAXIAL TERMINATIONS

PROTECTED UNDER STODDART PATENTS

This new group of pads and terminations features the popular Types C and N connectors, and permits any conceivable combination of the two styles.



PROTECTED UNDER STODDART PATENTS

six-position
TURRET ATTENUATOR

- **Frequency Range:** dc to 3000 mc.
- **Characteristic Impedance:** 50 ohms.
- **Available Attenuation:** Any value from 1 db to 60 db.
- **Accuracy:** ±0.5 db.
- **Power Rating:** One watt sine wave power dissipation.

STODDART
Aircraft Radio Co., Inc.
6644-B SANTA MONICA BLVD.
HOLLYWOOD 38, CALIF. • HO 1-9294

INDUSTRIAL NOTES ...

Microwave Electronics Division. Organization of the new Microwave Electronics Division of the Sperry Gyroscope Company has been announced. This reflects the company's increasing activity in large-scale programs for present and future surface and air defense systems, guided missile systems, and other vast radar and electronic systems for the armed forces. The division will employ more than 800 persons, including 200 engineers for streamlined supply to the military and industry of weapon support systems, Microline (trade mark) test equipment, antennas, and precision components requiring specialized engineering and production techniques. Also, reorganized and expanded operations for additional instrumentation and standards for advanced research laboratories, special radar systems, and target simulators, computers, and evaluators for radar, electronic, and inertial guidance systems will be handled. Employees presently engaged in this work are being integrated with the new division.

Lightning Rods Resist Corrosive Gases. The producers of lightning protection equipment, have found that ordinary lead-coated copper rods are inadequate on the heavy duty stacks of power, coke and gas plants, and incinerators, and the Carl Bajohr Company now installs rods with terminal sections made of Monel nickel-copper alloy. The combination of heat and corrosion from stack gases damages the lead coated upper rods. Under normal conditions, the corrosion problem has been overcome by a lead covering on the upper

25 feet of a copper conducting system. But, the high temperature of some industrial stacks melts off the lead covering and exposes the copper. The nickel-copper alloy not only has greater strength and adequate electrical properties for lightning rod applications, but also needs no coating; it is corrosion-resistant all the way through. This Monel alloy also is used to assure maximum service from bolts, screws, and hardware used to fasten the conductors to the stack.

Semiconductor - Components Division Formed. The Semiconductor Products and Components Divisions of the rapidly expanding Texas Instruments (TI), Inc. have been combined to gain advantages throughout the engineering, manufacturing and marketing operations. This action improves customer service and increases production efficiency. The Semiconductor Products Division manufactures germanium and silicon transistors and diodes. Recent introduction of vhf grown-diffused transistors and single junction rectifiers has broadened the range of application for semiconductor devices. The Components Division has expanded by addition of the product lines of Radell Corporation and Burlington Instrument Company to the established TI line of transformer-type components. The products of these divisions being marketed to the same electronics manufacturers and used in the same equipment and systems have improved customer service in sales. Engineering service is also provided by the consolidation.

Automatic Teletypewriter Switching Center. A fully Automatic Teletypewriter Switching Center began operation on the West Coast recently, it will handle more traffic with greater accuracy, using fewer people. Increased capabilities of the center will have immediate bearing on the number of military messages handled by the Army communications system. The global system is called the Army Command and Administrative Network. Occupying nearly 10,000 square feet of space, the center has 100 lines of fully automatic teletypewriter equipment. Signal Corps trained army personnel will operate the equipment.

Nuclear Power Station. Dresden Nuclear Power Station, which is to be owned and operated by Commonwealth Edison Company in co-operation with Nuclear Power Group, Inc., will be constructed 47 miles southwest of Chicago, Ill., at the point where the Des Plaines and Kankakee rivers meet to form the Illinois River. The station, which is to have capacity of 180,000 kw, is the largest all-nuclear power plant yet scheduled in the country. The plant will be of the boiling water reactor type which was developed by Argonne National Laboratory. The station is to be built by General Electric Company at a cost of $45 million. Commonwealth Edison will pay $30 million of this price plus the cost of the site and overhead costs. The remainder of $15 million is to be paid as a research and development expense by the eight companies comprising Nuclear Power Group. In addition to Commonwealth Edison these are: American Gas and Electric Service Corporation, Bechtel Corporation, Central Illinois Light Company, Illinois Power Company, Kansas City Power and Light Company, Pacific Gas and Electric Company, and Union Electric Company of Missouri. On the basis of the costs being capitalized by Commonwealth, which do not include the $15 million of research and development expense, the plant is expected to produce electricity on a basis competitive with a modern coal-fired station.

(Continued on page 79A)

Industrial Notes

(*Continued from page 14A*)

General Purpose Motor Controls Plant. The use of general purpose industrial controls will double within the next 8 to 10 years and General Electric Company's General Purpose Control Department is one of the newest manufacturing, engineering, and laboratory facilities in the country devoted exclusively to their manufacture. The trend toward automatic production in industry will result in an even stronger and healthier economy, with more jobs and increased prosperity. Products manufactured at the new plant, which is the department's headquarters, range from motor starters and controllers to push buttons and switches. The major product line consists of manual and magnetic motor starters that control motors up to 200 hp, used to drive equipment such as machine tools, pumps, compressors, industrial fans, blowers, and conveyors. Control devices used to make manufacturing processes more automatic, such as limit switches, solenoids, indicating lights, selector switches, relays, contactors, and compensators are also built here.

Building Construction. Plans for construction of a new $350,000 administration building are announced by the Electric Motor Division of A. O. Smith Corporation as the opening phase of a two-year expansion and re-equipment program expected to cost $3.25 million. Other major portions of the expansion of the division's operations at nearby Tipp City, Ohio, include, a manufacturing plant addition and new machinery and equipment. A 50 per cent increase in the Electric Motor Division's productive capacity is expected. The division makes special purpose lines of fractional integral and hermetic electric motors ranging in horsepower from 1/4 to 125. Much of the new equipment will consist of precision machinery designed to improve methods and to offer the division's motor customers a higher quality product.

Ultramodern Electronics Plant. Construction of an ultra-modern electronics plant for the Westinghouse Electric Corporation, which will be adjacent to Westinghouse air arm division plant, began December 1955 and is scheduled for completion July 1, 1956. The new facility will

(*Courtesy Westinghouse Corporation*)

provide for the manufacture of radar, fire control, and missile guidance systems. Engineering laboratories and administrative offices will occupy additional room.

(*Continued on page 24A*)

BIDDLE *Instrument News*

Biddle Motor and Phase Rotation Tester

(*Dual Purpose*)

With it you can . . .

- **Determine the direction of rotation of electric motors before they are connected to the line.**
- **Determine the phase rotation or sequence of energized power circuits.**

Here is a positive means for determining which motor leads must be connected to certain conductors of a supply system to insure that the motor will rotate in a prescribed direction when energized.

This device will permit the electrical contractor or industrial maintenance electrician to permanently connect and tape the terminals of the motor being installed, without having to first energize the motor by a temporary "hook-up" from a power source, if available, to determine its rotation.

Housed in a sturdy oak case 12¼" x 8¼" x 4¼" this compact unit weighs approximately 10 pounds and is supplied complete with 3 line and 3 motor leads which store in the compartments either side of the instrument panel.

For complete details write for **Bulletin 80-EE.**

Biddle Dielectric Test Set Model 1-40 KV

—for measuring d-c current at voltages up to 40 kv when applied to the insulation of such equipment as generators, transformers, bushings and cable.

Carefully considered safety features, excellent output voltage regulation, simple operation, compact design, and facilities for making voltage and current measurements at either polarity have been incorporated in this test set.

The set has a current rating of 25 milliamperes at short circuit, and current measurements can be made down to 0.5 microamperes which is the first division on the microammeter.

Overall dimensions are: height 19½ in., width 13½ in., depth 20 in., weight 120 lbs. All high voltage components are oil immersed.

For complete details, description, specifications, and prices, write for **Bulletin 22-EE.**

James G. Biddle Co.
1316 Arch St., Phila. 7, Pa.

Gentlemen: Please send me

☐ **Bulletin 80-EE**
☐ **Bulletin 22-EE**

NAME

JOB FUNCTION

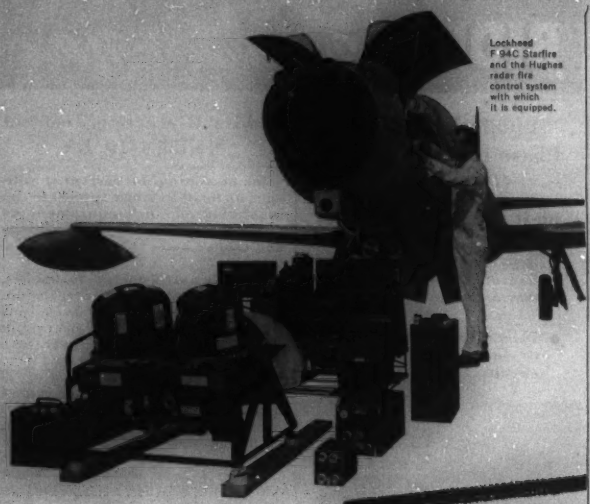
COMPANY

ADDRESS 8-600

JAMES G. BIDDLE CO.

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.



Lockheed F-94C Starfire and the Hughes radar fire control system with which it is equipped.

Hughes has been the leader from the beginning in applying electronic computers to airborne fire control equipment. Today every U.S. Air Force and Canadian continental defense interceptor uses Hughes-developed and Hughes-manufactured systems.

Product Design at

HUGHES WEAPON SYSTEMS DEVELOPMENT LABORATORIES

As the intercept problem becomes more and more automatic, additional equipment such as new-type computers, control surface tie-in (CSTI), autopilots, and other units must be integrated into the system. Faster speed and heavier engines dictate more streamlining—and hence less space for electronic gear. The result is even more miniaturization and compact packaging, evolved from special techniques.

This all means that now the product design engineer is more important than ever before. In the Product Design Laboratory he is a vital part of the formal link between the Research and Development activity and the optimum configuration and installation arrangements for the systems "black boxes."

HUGHES *Scientific Staff Relations*

RESEARCH AND DEVELOPMENT LABORATORIES

HUGHES AIRCRAFT COMPANY

Culver City, Los Angeles County, California

These positions in the Product Design Laboratory are open now in the Weapon Systems Development Laboratories:

IN THE GUIDED MISSILE AREA

ENGINEERS

to work on design and construction of microwave components.

ENGINEERS

to engage in the design and fabrication of airborne telemetering equipment for guided missiles.

ENGINEERS

to participate in development, design and prototype construction of electrical and electrohydraulic power supplies.

IN THE RADAR FIRE CONTROL AREA

ENGINEERS

to do equipment development and circuit design on special military field test equipment for support of fire control radar, fighter identification, and armament auxiliary equipment.

ENGINEERS

for circuit and equipment development in the field of airborne communication and navigation circuits.

ENGINEERS

experienced in computer or related fields to develop military field tests and auxiliary equipment for support of airborne computers.

You are invited to send resumes of your education and experience to the address at left.

VACATIONING IN SOUTHERN CALIFORNIA? YOU ARE INVITED TO VISIT HUGHES.

NEW

ISOG

for continuous performance at 15

Natvar Isoglas gives heavy duty equipment extra protection against frequent overloads beyond Class B rating. This glass fabric, coated with a newly developed isocyanate type resin is outstanding in its

- resistance to heat
- resistance to crazing and cracking
- resistance to solvents including the askarels
- toughness and abrasion resistance
- wet dielectric strength
- low temperature flexibility
- fungistatic qualities.

Natvar Isoglas may now be used with great savings where expensive Class H materials were formerly used to solve temperature problems during manufacture of transformers, motors, generators, converters, heavy duty relays, reactors and other types of equipment not requiring a Class H rating.

Technical data and samples are available on request.

NATVAR CORPORATION

FORMERLY THE NATIONAL VARNISHED PRODUCTS CORPORATION

TELEPHONE RAHWAY 7-8800

CABLE ADDRESS NATVAR, RAHWAY, N. J.

203 RANDOLPH AVENUE • WOODBRIDGE, NEW JERSEY

Natvar

Natvar Products

- Varnished cambric—cloth and tape
- Varnished canvas and duck
- Varnished silk and special rayon
- Varnished—Silicone coated Fiberglas
- Varnished papers—rope and kraft
- Slot cell combinations, Aboglas®
- Isoglas® sheet, tape, tubing and sleeving
- Vinyl coated—varnished—lacquered tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

Ask for Catalog No. 23

RADIO
INTERFERENCE
AND FIELD INTENSITY
measuring equipment

Stoddart equipments are suitable for making interference measurements to one or more of the following specifications:

Air Force — MIL-I-6181B
150 kc to 1000 mc
BuAer — MIL-I-6181B
150 kc to 1000 mc
BuShips — MIL-I-16910A (Ships)
14 kc to 1000 mc
SIGNAL CORPS — MIL-I-11683A
150 kc to 1000 mc
SIGNAL CORPS — MIL-S-16379A
150 kc to 1000 mc

The equipments shown cover the frequency range of 14 kilocycles to 1000 megacycles.

Measurements may be made with peak, quasi-peak and average (field intensity) detector functions.

F.C.C. PART 15 — Now in effect, the revised F.C.C. Part 15 places stringent requirements upon radiation from incidental and restricted radiation devices. Stoddart equipment is suitable for measuring the radiation from any device capable of generating interference or c-w signal within the frequency range of 14 kc to 1000 mc.

Write Stoddart Aircraft Radio Co., Inc., for your free copy of the new revised F.C.C. Part 15.

NM-10A (AN/URM-9B)
14 kcs to 250 kcs

NM-20B (AN/PRM-1A)
150 kcs to 25 mcs

NM-30A (AN/URM-47)
20 mcs to 400 mcs

NM-50A (AN/URM-17)
375 mcs to 1000 mcs

The **Stoddart NM-40A** is an entirely new radio interference-field intensity measuring equipment. It is the commercial equivalent of the Navy type AN/URM-41 and is tunable over the audio and radio frequency range of **30 CPS to 15 kc.** It performs vital functions never before available in a tunable equipment covering this frequency range. Electric and magnetic fields may be measured independently over this range using newly developed pick-up devices. Measurements can be made with a 3 db bandwidth variable from 10 CPS to 60 CPS and with a 15 kc wide broadband characteristic.

STODDART *Aircraft Radio Co., Inc.*
6644-B SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA · Hollywood 4-9294

Industrial Notes

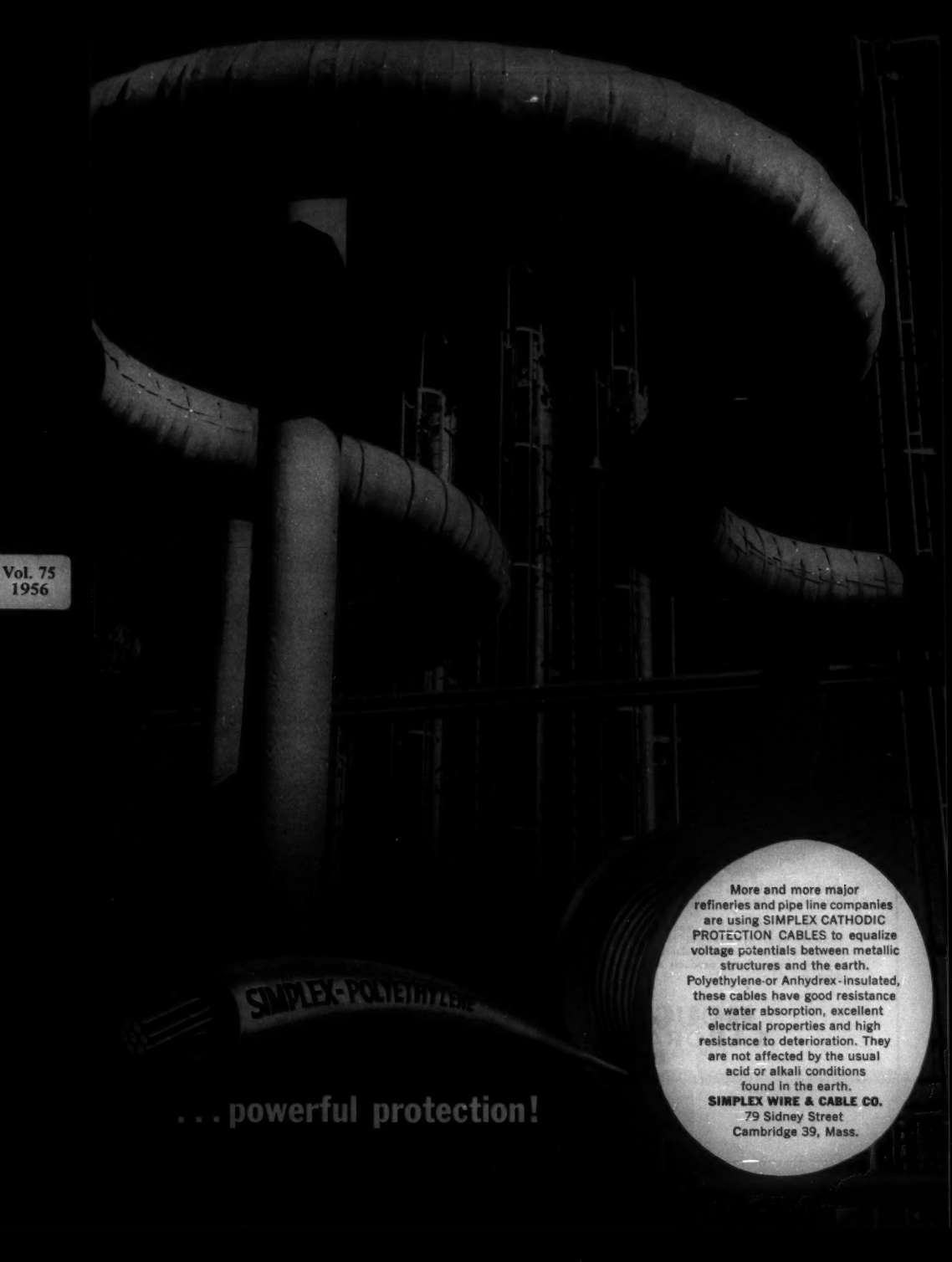
(*Continued from page 19A*)

It will be the most modern facility in America for advanced design, development, and manufacture of land-based and ship-borne electronics. The plant will be divided into three sections. The 2-story engineering building will be 580 feet long and 120 feet wide. The manufacturing section, largest of the three, 840 feet long and 240 feet wide, will be adjacent and connected to the engineering section. The third section, the antenna tower building, now nearing completion, will be located on the southwest corner of the manufacturing section.

Plant Addition. Plant space added to its facilities in Stamford, Conn., has been announced by Consolidated Diesel Electric Corporation. Reflecting the increasing volume and scope of manufacturing by Con Diesel, this expansion program includes additional engineering space, and modernization and improvement of existing facilities and equipment. Con Diesel, which designs, engineers, and produces specialized lines of aircraft servicing and testing equipment, and electric generating equipment, moved to Stamford in 1950. The most recent acquisition, involving lease of 15,000 square feet of additional plant space, resulted from the rapid growth of Con Diesel's test equipment division, which produces precision electric, hydraulic, fuel, pneumatic, and mechanical testing equipment, and automation. The new plant is located at 1 John Street, Stamford, Conn. The enlarged space for the engineering department is being constructed adjacent to Con Diesel's main plant at Canal and Ludlow Streets. Other developments include renovating the exterior of the corporation's main office building, constructing a visitor's reception room, additional parking space for visitors and employees, and new loading ramps for the main plant.

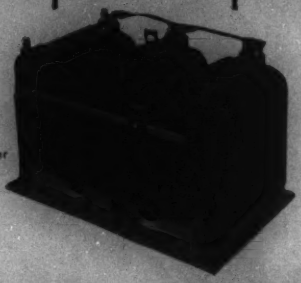
New Laboratory. Nuclear Science and Engineering Corporation (NSEC) of Pittsburgh is building a new and additional laboratory facility on a $3\frac{1}{2}$ acre site near the Allegheny County Airport. The new laboratories reflect NSEC's expanding programs in the field of radiobiology. Radiation sterilization of food, radiation sterilization of sewage, study of radiation effects on living organisms, irradiation induced toxic factor, health-physics determinations, and other programs relating to nuclear aspects of biology and medicine will take place in the new building. The rapid growth and development of NSEC is indicative of Pittsburgh's unique position in the atomic energy industry. The Corporation has developed extensive nuclear projects that relate to industrial utilization of nuclear techniques aiding the nuclear power industry through a wide variety of radiation services.

(*Continued on page 30A*)


Vol. 75
1956
SIMPLEX-POLYETHYLENE
. . . powerful protection!
More and more major refineries and pipe line companies are using SIMPLEX CATHODIC PROTECTION CABLES to equalize voltage potentials between metallic structures and the earth. Polyethylene-or Anhydrex-insulated, these cables have good resistance to water absorption, excellent electrical properties and high resistance to deterioration. They are not affected by the usual acid or alkali conditions found in the earth.
SIMPLEX WIRE & CABLE CO.
79 Sidney Street
Cambridge 39, Mass.

HYSOL 6600

epoxy casting resin



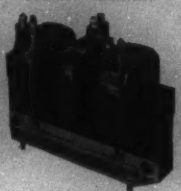
3-phase plate transformer (2½ KVA)

For These RAYTHEON Transformers . . .

Filament Transformer

HYSOL 6600 is a new epoxy casting resin especially developed for MIL-T-27A and other Military Specifications. After more than two years of development and evaluation in our own and government laboratories, it is now being economically used in transformer production by RAYTHEON.

HYSOL 6600 was specifically produced for transformers for electronics, instrument transformers, power bushings and related equipment. It is a filled epoxy base in the form of a soft solid which melts to a low viscosity liquid. Complete Technical Data Bulletin available on request.



Dual high-reactance Filament Transformer

Houghton Laboratories manufactures complete lines of Electrical Insulating Materials, Adhesives and Sealants, Tooling Materials and cast products as rod, sheet and tube.

PROGRESSIVE PRODUCTS HYSOL Product of HOUGHTON LABORATORIES, INC. THRU CHEMICAL RESEARCH

HOUGHTON LABORATORIES INC.

105 HOUGHTON AVE. OLEAN, NEW YORK

In Canada

HYSOL (Canada), LTD.

Leaside, Toronto 17, Ontario

(*Continued from page 24A*)

NEW PRODUCTS

Thermocouple Reference Junction. Developed for use with multichannel temperature measuring systems, the model *RJ-1* thermocouple reference junction provides thermostatically controlled temperature reference for thermocouple circuits, eliminating necessity for cold-junction compensation and ice-bath maintenance. There are 24 thermocouples included in the reference junction, with a choice of iron-constantan, chromel-alumel, or chromel-constantan in each of 12 independent circuits. At a reference temperature of 150 F, the rated accuracy is ±1/2 F under normal ambient conditions. Others are offered with varied arrangements in input and output coupling, thermocouple types, and number of circuits. The reference junction is also available as part of an integrated control and calibration system for oscillographic recording. The model *RJ-1* weighs 15 pounds, measures 8 by 10 by 10 inches, and operates from a 115-volt line. Address inquiries to Bernard Helfand, Pace Engineering Company, 6914 Beck Avenue, North Hollywood, Calif.

Cathode Ray Tube Retains Traces. Hughes Products, a division of the Hughes Aircraft Company, has announced that a new direct display storage tube is now in production and is available for industrial and labratory use. The new cathode ray tube, named Memotron, can capture and retain visual displays of transients without resorting to photography. Utilizing a special storage target just behind the viewing screen, this 5-inch tube retains single tracings or successive writings at high brightness, until they are intentionally erased. Photography need be used only when permanent records of selected traces are required for files. One calibration of photographic exposure is sufficient, since all tracings have the same brightness. High light output permits the Memotron to be used in well-lighted areas without a hood. According to the manufacturer, some general specifications of the Memotron are as follows: resolution, 60 written lines per inch; brightness, 50 foot-lamberts; usable screen diameter, 4 inches, minimum. Descriptive literature is available from Hughes Products, Los Angeles 45, Calif.

Tan-O-Mite Tantalum Capacitors. A line of ultrasmall tantalum capacitors, designated as Series *TW* Ohmite Tan-O-Mite capacitors, has just been announced by Ohmite Manufacturing Company of Skokie, Ill. The Tan-O-Mite capacitors are subminiature size units specially designed and developed for transistorized electronic equipment where small space and high reliability are of great importance. Tantalum capacitors are more stable, have much better shelf life, produce greater capacity in a given size, and are usable over a wider temperature range than aluminum

(*Continued on page 34A*)

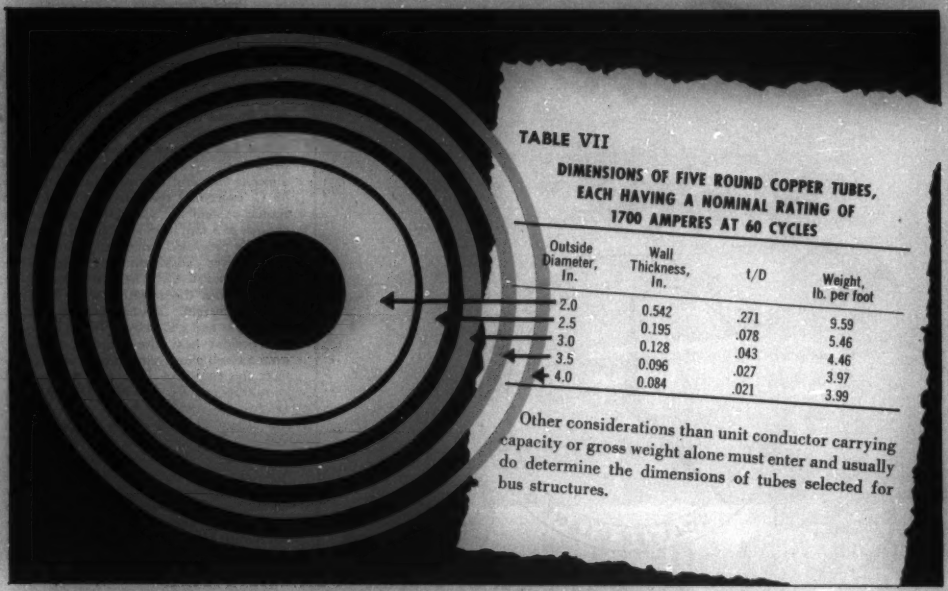


TABLE VII

DIMENSIONS OF FIVE ROUND COPPER TUBES, EACH HAVING A NOMINAL RATING OF 1700 AMPERES AT 60 CYCLES

Outside Diameter, In.	Wall Thickness, In.	t/D	Weight, lb. per foot
2.0	0.542	.271	9.59
2.5	0.195	.078	5.46
3.0	0.128	.043	4.46
3.5	0.096	.027	3.97
4.0	0.084	.021	3.99

Other considerations than unit conductor carrying capacity or gross weight alone must enter and usually do determine the dimensions of tubes selected for bus structures.

Reducing Bus Costs with Thin-Wall Tubes

Where mechanical requirements permit, bus costs can be cut through the use of tubular bus conductors with low wall-thickness-to-diameter ratios.

The chart above shows how the weight of metal purchased goes down as the t/D goes down for five round copper tubes of the same nominal current-carrying capacity.

What is true of round tubes is also true of other tubular bus shapes—low wall thickness giving decided electrical advantages.

Round tubes in the standard pipe dimension, and thin-wall sizes also offer other advantages. You can utilize the great variety of stock sizes of supports, connectors, clamps, and other hardware in dealers' stocks.

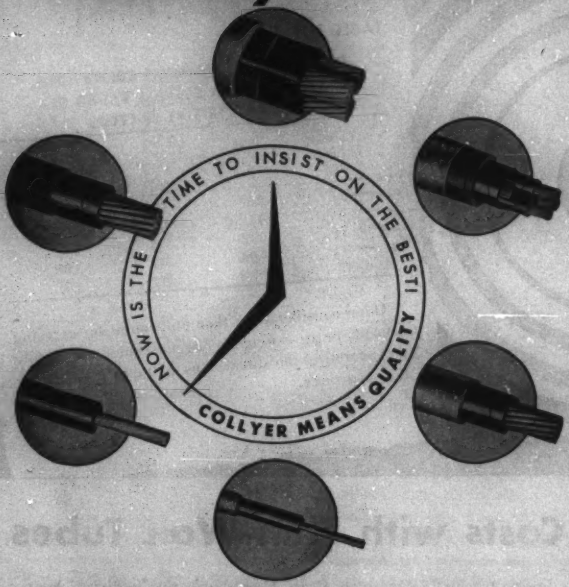
For more complete information on the use of thin-wall tubes see the brand-new Fifth Edition of The American Brass Company's publication, "Anaconda Copper for Electrical Conductors." This 62-page booklet has a wealth of general information on the properties of electric conductors – plus convenient tables giving the electrical and mechanical properties of copper bus conductors for all the most commonly used sizes of the popular shapes. Much of the material has not heretofore been published.

TECHNICAL SERVICE. The services of Anaconda specialists are available to help you in the solution of special problems involving the use of ANACONDA Bus Conductors. For such help—or for a copy of "Anaconda Copper for Electrical Conductors"—see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. B-8499

ANACONDA® COPPER CONDUCTORS

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED

IT'S Collyer TIME!



. . . any time you need

INSULATED WIRES & CABLES

Our product line includes:

Aerial Cables
Apparatus Wires and Cables
Asbestos Insulated Wires and Cables
Asbestos and Thermoplastic Insulated Wires and Cables
Asbestos and V.C. Insulated Wires and Cables
Elevator Control Cables
Grounding Cables
Heavy Duty Portable Cables and Cords
High Voltage Cables
Lead Sheathed Cables
Line Wire
Machine Tool Wires
Mining Machine Cables
Motor and Generator Leads
Network Cables
Neutral Supported Service Cables
Non-Metallic Sheathed Cable (Cablex)
Pole and Bracket Cables
Resistol* Insulated and Sheathed Cables
Rubber Insulated Power Cables
Service Cables
Station Control Cables
Street Lighting Cables
Switchboard Wires and Cables
Tree Wire
Underground Cables
Varnished Cambric Insulated Wires and Cables
Welding Cables

*Resistol is Collyer's Polyvinyl Thermoplastic Resin

Collyer

COLLYER INSULATED WIRE CO.
245 ROOSEVELT AVE., PAWTUCKET, R. I.

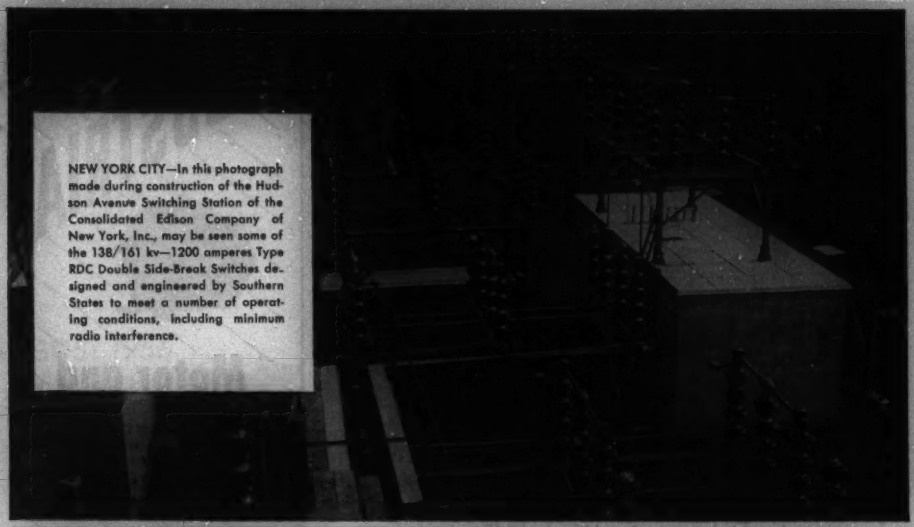
New Products

(*Continued from page 30A*)

electrolytic capacitors. Three nominal sizes cover a range of capacitance from 0.02 to above 30 μf. Coupling, filter, and by-pass requirements at low voltage d-c, in hearing aids, miniature portable radios, and military equipment are met by these units. Tan-O-Mite capacitors have a usable temperature range from −55 C to 85 C, exceeding the rated limits of other similar capacitors. Capacitor construction consists of a tantalum wire anode, having a specially processed oxide film, contained in a tiny silver cylindrical cup, which is the cathode (negative). The case is electrically live and has the negative wire lead fastened to the end. The case is filled with an electrolyte and sealed by a Teflon bushing. The positive lead wire is radial, emerging from a small plastic embedment which protects the tantalum lead and the welded joint. The wire can be bent readily to an axial position when both leads are desired this way. The plastic protection feature makes Tan-O-Mite capacitors easy to connect with a minimum of care. Every capacitor is aged under operating conditions. They are tested 100 per cent for capacitance, power factor, and d-c leakage current. For additional information write to Ohmite Manufacturing Company, 3625 Howard Street, Skokie, Ill., asking for Bulletin *148*.

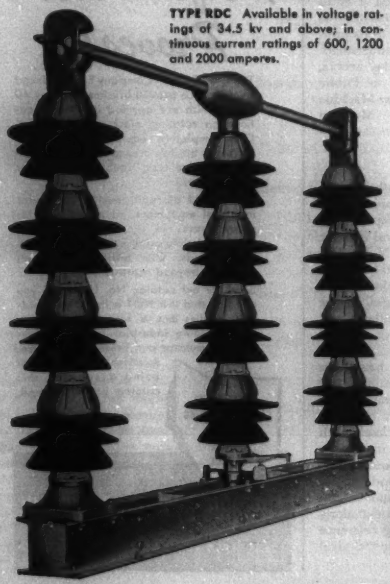
Toroid Coil Winder. Electro Devices Company, Inc., announces the availability of the new Midjet Toroid Coil Winder. The new Midjet Toroid Coil Winder eliminates tedious hand winding, insures uniform products, permits precise winding control and provides extreme operational simplicity. This compact and portable machine is exceptionally versatile and permits winding finished coils having an ID as small as $^3/_{32}$ of an inch. A unique method of winding off the inside of the shuttle instead of the top makes this possible. Maximum finished coil diameter is 1 inch, and the maximum height, measured along the toriod axis is $^1/_4$ inch. Wire sizes from 30 gauge to 46 gauge can be used with the Midjet as well as extremely fine wire sizes without the usual wire breakage and production slowdown. The Midjet, therefore, may be used to wind coils common to transformers, magnetic amplifiers, saturable core and filter elements, and data machines. High winding speeds from 0 to 200 turns a minute for volume production are possible with the Midjet. These high winding speeds are accomplished without tensile shock to the entire range of wire sizes of the type that causes breakage. Polished winding guides confine the wire to a simple plane between shuttle and core. The wire flows through the hardened and highly polished vent in the shuttle thus preventing kinks and loops. Entire shuttle is highly polished to avoid scarfing or abrasion to the inner surface of the coil and insulation on the wire. Complete information on the Midjet can be obtained from Electro Devices Company, Inc., 580 Main Street, Wilmington, Mass.

(*Continued on page 38A*)



NEW YORK CITY—In this photograph made during construction of the Hudson Avenue Switching Station of the Consolidated Edison Company of New York, Inc., may be seen some of the 138/161 kv—1200 amperes Type RDC Double Side-Break Switches designed and engineered by Southern States to meet a number of operating conditions, including minimum radio interference.

Consolidated Edison Picks Type RDC Switches For its Hudson Avenue Switching Station



TYPE RDC Available in voltage ratings of 34.5 kv and above; in continuous current ratings of 600, 1200 and 2000 amperes.

The newest member of Southern States' complete line of air break switches was chosen by Consolidated Edison for its recently completed Hudson Avenue Switching Station.

The Type RDC has an RIV of less than 500 microvolts, a primary requirement for this station located in Brooklyn, New York.

There are many other advantages of this double side-break switch, including:

- **High momentary current rating**
- **Streamlined, corona-suppressing contours**
- **Minimum number of current interchange points**
- **Shuntless design**
- **Wide angle blade rotation**
- **AMPLITACT® silver-to-copper contacts**
- **Shielded mechanisms—complete icing protection**
- **Greaseless, non-corroding ball bearings**
- **Switch blade is one continuous member**

Your Southern States representative will be glad to give you more information about this new switch.

SOUTHERN STATES
EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

FOUR-CHANNEL CARRIER-TELEPHONE TERMINAL FOR RADIO LINKS

This is a miniaturized unit of advanced design which provides four voice channels on a frequency-division basis above a voice-frequency order-wire channel. Each of these five channels is provided with a 4-wire 2-wire termination and a voice-frequency ringing circuit for d-c or 20-cycle signals. Adjustable attenuators are provided in the 4-wire side of all channels, and a built-in test oscillator and meter permit complete line-up, maintenance and trouble-shooting checks to be made. Channel levels are from −9 to 0 dbm and line levels from −30 to 0 dbm. Channel width is 300 to 3500 cycles within 1 db.

This unit is only 5¼" high by 19" wide by 14" deep. It mounts on a standard rack and operates from 115 volts 50-60 cycles a.c.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE University 6-6887 CABLES RADENPRO MONTREAL

TRADE LITERATURE

(*Continued from page 34A*)

Variable Speed Drive Booklet. A 44-page booklet carrying handy multicolor tables for quick and easy selection of variable speed Texrope drives has been released recently. In addition to providing selection tables for A, B, C, and D section variable speed drives, the booklet includes information on design features, drive principles, horsepower rating tables for A, B, C, D, and E section belts, a speed range table showing the variation in revolutions per minute when using two Vari-Pitch sheaves in combination, and accessory equipment for the Vari-Pitch drive. Copies of the booklet, Variable Speed "Texrope" Drives, *20P50*, are available on request from Allis-Chalmers Manufacturing Company, 931 S. 70th Street, Milwaukee, Wis.

Reprints of Relay Specification. A special printing of a 12-page article on "Specifying Relays" has just been released by American Machine and Foundry Company. The article covers the various factors that should be considered in selecting an electrical relay for a given application. These factors include circuit characteristics, type of switching, actuation power, operating speed, duty cycle, life expectancy, environmental conditions, physical requirements, and cost. The electromagnetic relay can be tailored to provide high conductance switching of almost any conceivable combination of currents and voltages and can be operated by power from a wide variety of sources. However, in order to apply such a component properly and most successfully, its performance capabilities as well as its limitations should be thoroughly understood. To obtain a free copy of the relay article, write on company letterhead to Public Relations Department, American Machine and Foundry Company, 261 Madison Ave., New York 16, N. Y.

Turnpike and Expressway Lighting. A 28-page bulletin dealing exclusively with the lighting of turnpikes and expressways is now available from the General Electric (GE) Company, Schenectady 5, N. Y. The publication, designated *GED-3001*, devotes special attention in separate sections to the lighting of toll plazas, interchanges, service areas, main traffic lanes, bridges and viaducts, tunnels and underpasses, and special purpose lighting. Listed are recommendations for lighting hazardous areas on modern, high speed turnpikes and expressways. The recommendations offered by GE lighting experts are based on more than 30 years of working closely with local, state, and Federal officials in lighting many of the country's limited-access roadways. Sections dealing with fundamental aspects of roadway lighting and fundamental design objectives are included along with three full pages of lighting reference data dealing in lay terms with the technical aspects of the problem.

INDUSTRIAL
Motor and Generator Brushes
Performance Proves!
The Ohio Carbon Company has produced performance proven brushes for over 40 years which are applied in all applications on rotating electrical equipment. Our completely equipped laboratory develops brushes in a grade of material that will give long trouble-free life for specific uses.
In the field of replacement brushes for industrial equipment we have been for many years the leaders in providing brush materials adapted to actual operating needs. Our brush replacement service is beyond reproach.
Send for our catalog No. 18-A and you will find that it is NOT a listing of standard brushes but a complete guide to understanding industrial brush construction, commutator and brush maintenance.
A letterhead request will bring a copy of this catalog by return mail.
ORDER YOUR CARBON BRUSHES FROM A SINGLE SOURCE
Over 40 Years of Experience in this field!
THE OHIO CARBON COMPANY
12508 BEREA ROAD • CLEVELAND 11, OHIO